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ORIGINAL ARTICLES.

I.—The Directorship of the Natural History Museum.

THE retirement of Sir William Flower from the office of Director of the British Museum of Natural History, which took place on September 30, after fourteen years of extremely efficient and active service, will be viewed with regret by the great majority of naturalists throughout the country. That he achieved the completion of all his plans would be to claim too much in so limited a period of time, but that he succeeded in illustrating how a Natural History Museum may be rendered attractive to the general public and may also be a place of instruction to the student, no one will deny.

The cases illustrating structures in the skeleton and dermal covering of mammals, birds, reptiles, and fishes, along the western side of the Great Hall, and those of insects, mollusks, sponges, and plants, upon the eastern side, convey an admirable idea how a teaching series should be arranged; whilst the groups of mammals, birds, and insects in the glazed cases on the floor of the Hall illustrate how the general public may be attracted and interested in Natural History.

For the arrangement of the beautiful series of nesting birds, with eggs and young, in their natural surroundings, so liberally presented to the nation by Lord Walsingham and other donors, the public is indebted to Dr. Günther, F.R.S., for so many years the able Keeper of the Zoological Department, aided by Dr. R. Bowdler Sharpe and other members of the staff. Sir William Flower had undertaken the reorganization and rearrangement of the entire exhibited collection of mammals and birds, the former of which, with the aid of Mr. R. Lydekker, F.R.S., he had largely carried through, but of the latter only a small portion has as yet been accomplished. Sir William Flower's last efforts were devoted to complete the exhibition of Cetacea in the new Whale Room, in which models of right whales and toothed whales are shown with their skeletons, giving an admirable idea of both the exterior and the bony framework of these huge marine mammals such as has never before been displayed in this country, although previously initiated in America.

Writing on behalf of the Trustees, Lord Dillon, Chairman of the Standing Committee, said "they wished to record their high appreciation of his services, and of the rare combination of wide

scientific knowledge with marked administrative ability with which he had carried through his difficult task. Under his direction the Natural History Collections have been so arranged that no one can examine them without admiration. To Sir William Flower, as a worthy successor of Sir Richard Owen, will attach the honour of having organized a museum which now occupies a prominent position among all the museums of the world. For these services the Trustees offer their hearty thanks and sincere good wishes on his retirement."

The new Director—Professor E. Ray Lankester, M.A., LL.D., V.P.R.S., Linacre Professor of Comparative Anatomy, etc., Fellow of Merton and Hon. Fellow of Exeter College, Oxford, born 1847, the eldest son of the late Dr. Edwin Lankester—occupies a most distinguished position as a naturalist and zoologist, and carries with him the support of a large majority of the leading men of science throughout the country. He will doubtless ably achieve the completion of the arrangement of the zoological collections which fall immediately under his charge as Keeper, in addition to the office of Director of the whole Museum. He is to be congratulated upon succeeding such eminent predecessors as Owen and Flower, whose honourable careers have added lustre to the post upon which he will enter to-day with the good wishes of all his scientific friends.

II—Discovery of a second Specimen of the Fossil Egg of *Struthiolithus*.

By C. R. Eastman, Esq.,
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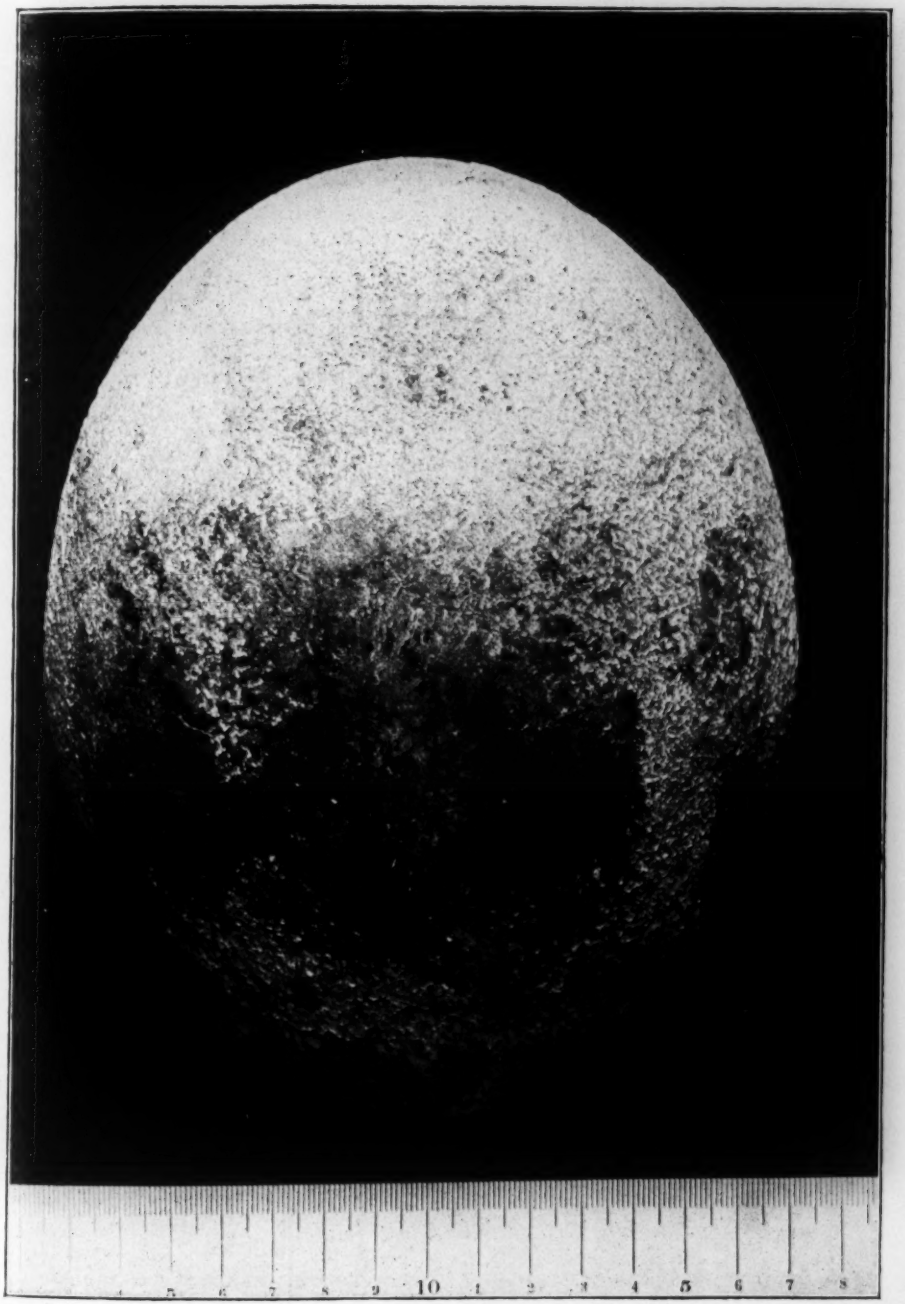
(PLATE XVII.)

In the year 1857, or thereabouts, a remarkable fossil egg was discovered in the Government of Cherson, in South Russia. The circumstances of its being brought to light were peculiar, and its subsequent history is instructive enough to repay a brief recapitulation, which we give as follows.

During a freshet, a stream occupying an old watercourse excavated a recess below a milldam not far from Malinowka, in the Chersonesus. Some peasants happening to pass along at the time observed floating on the surface of the pool an egg-shaped object, which they immediately captured. Happily their curiosity as to its nature was so far tempered by mercenary instincts that they did not break it, and after several exchanges of ownership it was finally offered for sale by a man named Dobrowolsky to various scientific institutions of Russia for the sum of one thousand roubles. In the course of time it was submitted to Professor Kessler, of Kiev, for examination; and some years later to Professor Alexander Brandt, of Charkow, who obtained permission to take a plaster cast of the specimen, and also prepared a description of it, which attracted considerable attention.[1] The owner of the egg, however, although disappointed

[1] Bull. de l'Acad. Imp. des Sci. St. Petersburg, vol. xviii (1873), pp. 158–161. Translated in *Ibis* [3], vol. iv (1874), pp. 4–7.



Egg of *Struthiolithus Chersonensis*, Brandt.

Found in a Post-Tertiary deposit at Kalgan, Hsi Ning, Northern China.
(Reduced about one-third natural size.)

in realizing the high price set upon his treasure, was unwilling to part with it for less, and it consequently remained in possession of the family for many years. But ultimately a sad fatality overtook it. Through some accident it was shattered into nearly forty pieces, and its commercial value being looked upon as ruined, steps were taken to present it to the St. Petersburg Museum, where we understand it is now preserved, the fragments having been restored as well as possible.

Professor Brandt was apprised of the loss at the time, and forthwith communicated the intelligence to the *Zoologischer Anzeiger*.[1] This prepared the way for W. von Nathusius to obtain a fragment for microscopic investigation, the results of which were shortly afterwards published in the same journal.[2] Nathusius found the shell structure so similar to that of the common ostrich that he did not hesitate to declare the parent bird must have belonged to the genus *Struthio*. Professor Brandt, however, in view of the extraordinary size of the egg, and the fact that no fossil bones were discovered which might throw light on its relationships, had already proposed the new genus *Struthiolithus*, for the reception of both the ovulite and its as yet unknown parent bird. Now, as most persons are aware, egg-shells vary considerably in structure, even when those of the same species are compared; in some cases, indeed, if one had but the mere shells to deal with, he might infer greater differences between the birds laying them than actually exist. On this account, and in lieu of specific anatomical evidence to the contrary, we prefer to follow Professor Brandt's example, and recognize *Struthiolithus* as a distinct genus until it shall be proved to be identical with some other known form. The specific title applied by Professor Brandt is *S. Chersonensis*, which up to the present time has been illustrated only by the unique type.

By great good fortune a second specimen has recently been brought to light, fully as perfect as the type, and agreeing with it so closely in form and dimensions that we cannot doubt for a moment it belongs to the same species. A comparison with the type was facilitated through the courtesy of Professor Brandt, who presented the Museum of Comparative Zoology at Cambridge, Mass., with a cast of the original. It is expected that this institution will eventually acquire the new example also, negotiations to that effect having been entered into, and for the present it is deposited there.

The history of the new specimen is as follows:—Four or five years ago a farmer in Northern China, while working at the foot of a bank of earth about six metres high, dug out what he considered to be a pair of 'dragon's' eggs. One was broken, the other entire, and presuming the latter to have some commercial value, he took it with him to Kalgan, and succeeded in selling it for a small sum to one of the American Board missionaries—the Rev. William P. Sprague, who was residing there. The Rev. James H. Roberts,

[1] Zool. Anzeiger, vol. viii (1885), No. 191, p. 191.
[2] Ibid., vol. ix (1886), No. 214, p. 47.

a brother missionary who has likewise spent many years in China, was present when the egg was sold, and on revisiting the United States last spring, brought the specimen with him at the instance of Mr. Sprague, to be offered for sale to some scientific establishment.

The Chinese workman who found the egg was well-known to the servants of the missionaries as a native of Yao Kuan Chuang. This is a small village in the district of Hsi Ning, about fifty miles south-southwest from Kalgan by road, but somewhat nearer in a straight line, as that region is very mountainous. Subsequently Mr. Sprague visited the exact spot where the eggs were dug up, in company with the man who found them, and thus satisfied himself of the authenticity of the discovery. The fragments of the second specimen were unfortunately not preserved, and as Mr. Sprague was in doubt whether the perfect one was indeed an egg, or perhaps only a geode, he made a small incision at one end to ascertain if there were crystals on the inside. But on illuminating the walls of the interior, they were found to present the same general appearance as the external surface, and a loose calcareous mass, partly in the form of powder and partly flakes that appear to have become scaled off from the inner surface, was found within the cavity. This mass is still preserved in the same condition as when found, and weighs 18·1 grams. Possibly it represents in part the calcified shell membranes, such as have been found fossilized in certain moa eggs. Examined with a pocket lens, the flakes present no appearance of having an organized structure. Without this interiorly contained mass, the shell weighs a trifle more than 310 grams. Its other dimensions are given in the following table, together with measurements of other large fossil eggs.

Comparative Dimensions of the Egg-Shells of Struthious Birds.

Name of Species.	Longitudinal axis.	Transverse axis.	Major circumference.	Minor circumference.	Capacity.	Weight.
	cm.	cm.	cm.	cm.	c. cm.	grams.
Æpyornis maximus, Geoff.	35·1	24·5	92·1	76·8	11,035·8	—
,, ,, ,,	34·0	22·5	85·0	71·0	9,012·5	—
,, ,, ,,	32·0	23·0	84·0	72·0	8,863·5	—
Dinornis, sp.	25·2	17·8	—	55·9	4,180·6	—
Struthiolithus Chersonensis, Bdt. (type)	18·0	15·0	52·0	46·0	2,075±	819±
Struthiolithus Chersonensis	18·0	14·75	51·35	46·45	1,896·9	310·05
Struthio camelus, Linn. ...	16·4	13·40	47·10	42·20	1,423·6	310·95
Rhea Darwinii (Gould) ...	13·5	9·45	35·85	29·90	570·44	79·89

It is probable that the Chinese specimen was only partially embedded in the soil when found, the evidence for this being that the greater portion of the surface is incrusted, more or less granulated, or otherwise affected by atmospheric erosion. The least

weathered side is that shown in the accompanying figure, reproduced from a photograph, and on this several areas are to be observed where the original shell has remained unaltered. Some discoloration has been brought about through the agency of iron oxide, and grains of ferruginous sand still adhere to the shell in places, or are even partially embedded in the crust. This side of the shell is of a brownish yellow colour, somewhat darker than the opposite or more weathered side. Numerous fine pittings are to be seen over the greater part of the periphery, especially in the equatorial region, some of which may be due to destructive agencies, but the majority of them are clearly to be regarded as the round terminal pores of air-canals. To determine their precise relationships it would be necessary to sacrifice a portion of one of the best preserved areas for the purpose of making a thin section, but as no such area is contiguous to the aperture at one end cut by Mr. Sprague, and as sections from the polar regions afford but little information, no further mutilation has been attempted. Indeed, it is doubtful in any case whether a section would show more than has already been ascertained from Nathusius's study of the type-specimen, which merely proved that the air-canals terminated in a similar fashion as in *Struthio camelus*.

As to the age of the deposit from which the specimen was exhumed, it is reasonably certain from the accounts furnished by Mr. Roberts and Mr. Sprague, the former of whom related his observations in full to the writer, that no earlier date can be assigned to it than the Pleistocene. The gravel bank yielding the remains is situated in a loess basin which is drained by the Sang Kan. Such basins are not uncommon along the upper course of this river, and are mentioned by Von Richthofen and Pumpelly in their works on the Geology of China. According to Von Richthofen, the superficial deposits of these basins were laid down over the bottom of isolated salt lakes having no outlet, and were afterwards buried by alluvial detritus. Traces of former shore-lines exist along the mountain sides, and one is confronted on every hand with the evidence of recent dessication. The moderate depth to which ravines have cut through the former lake beds, and the straight narrow gorge of the Sang Kan, through which their waters were drained off, corroborate the belief that this event took place at no very remote period—in all probability since the Pleistocene. The occurrence of fossil ostrich remains in such widely separated regions as Northern China and Russia during the late Tertiary has a signal bearing upon the distribution of Struthious birds. The only existing representative of the Struthionidæ (*S. camelus*) is confined to Africa and Arabia, but the Pliocene of the Siwalik Hills in India has yielded a closely related species (*S. Asiaticus*), and other remains, described as *S. Karatheodoris*, have been found in the Lower Pliocene of Samos. On the theory of the multiple origin of the Ratitæ, we are obliged to disclaim any genetic relationship between *Struthio* and other Oriental forms commonly classed as Struthious birds, such as the emeu, cassowary, and extinct wingless birds of New Zealand. But

with *Rhea* the case is different. No one can deny that the physical resemblances between *Rhea* and *Struthio* are very great; in fact, the popular term 'South American ostrich' is an obvious commentary on their similarity. Although both genera are regarded as typical of distinct families, and are even commonly placed in separate suborders, yet if one were asked to specify the nearest living ally of the African ostrich, he would unhesitatingly point to *Rhea*. Now either these resemblances are proof of actual blood relationship between the two genera, or else they furnish a most marvellous instance of convergence. The simplest, and as we believe, most natural interpretation, would be to regard forms so like one another as genetically related, at least until it is demonstrated that by no possibility could they have been descended from the same stock. To us it seems incredible that two separate derivatives of Carinate birds should become specialized in exactly the same manner in Africa and South America, and should assume such a close resemblance to one another, through the operation of fortuitous natural conditions, or as the result of adaptation. For the chances are slight indeed that the environment, of itself dissimilar, should act in such a way as to produce an identity of ultimate results out of originally heterogeneous material.

If *Rhea* had different progenitors from the ostrich, we are in utter ignorance as to what they were like, since no other descendants of the parent stock can be pointed out. That there is anything in common between *Rhea* and the Tinamous we cannot believe for a moment, owing to the very different organization of the latter. Captain Hutton's theory, therefore, which derives both *Rhea* and the moas from a Tinamou-like ancestor which crossed into Australia and New Zealand by means of an imaginary Antarctic continent, must be relegated on both biological and geological evidence to the same category as the Lemurian hypothesis.

Rhea still enjoys a comparatively wide distribution in South America, and its remains have been found in the bone caverns of Brazil. If the evidence of *Diatryma* from New Mexico means anything at all, it would point to a connection between a fossil North American and the existing South American ostrich. It is true that the late Tertiary yields no evidence of Struthious birds in North America. But it is also true that until the discovery of *Struthiolithus* under the shadow of the Great Wall in China, no one could have suspected the whole intervening territory between North-Eastern Asia, Russia, and South Africa to have been in comparatively recent times inhabited by genuine ostriches. The palæontological record is from the nature of things very deficient in the case of land birds, and many gaps can be filled up only on indirect evidence. One such hiatus is now partially filled by the occurrence of *Struthiolithus* in Northern China. A race having the constitutional vigour and numerical force to establish itself in this latitude—and in a mountainous region as well, where the struggle for existence is always intensified by a larger number of enemies than are encountered on the plains, to say nothing of the rigours of winter—

must have been able to penetrate still further northward, and might readily have accompanied the mammals that migrated across the land-bridge formerly connecting the Palæarctic and Nearctic regions.

In a word, if we can predicate any blood relationship between the African and South American ostriches, it is certain that the latter could have reached its present habitat in no other way than along the route marked by *Struthio camelus*, *S. Karatheodoris*, and *S. Asiaticus*, *Struthiolithus*, *Diatryma*, and the *Rhea* of Brazilian bone caverns. If any will presume to deny a relationship between *Struthio* and *Rhea*, they are confronted with these difficulties: to explain how two separate derivatives from Carinate stock should come to present such remarkable similarity to one another through the agency of purely fortuitous conditions, and to point out a lineage for *Rhea* connecting it more closely with Carinates than with the ancestors of *Struthio*. Sceptically inclined individuals are welcome to regard *Rhea* as one of the "waifs and strays of a lost avifauna left by the sea of time stranded on the shores of the present,"[1] but we personally prefer the more positive view, which connects the New and Old World ostriches in the manner indicated.

Further remarks on the distribution of Struthious birds, as well as a more extended account of the new specimen of *Struthiolithus*, illustrated by photographic reproductions, will be found in a forthcoming number of the Bulletin of the Museum of Comparative Zoology,[2] of which the present paper is largely an abstract.

III.—Blind Trilobites.

By F. R. Cowper Reed, M.A., F.G.S.

Introduction.

THE occurrence of certain genera and species of trilobites which are destitute of eyes has long been known, and so much importance was attached by Dalman to the presence or absence of the visual organs that he instituted two principal divisions of the trilobites based simply on these characters. Goldfuss followed the same lines in his system of classification, though he took into consideration also the structure of the eyes; and Emmrich likewise regarded the possession or lack of these organs to be of taxonomic value. Although in modern schemes of classification more stress is laid on other features of the organization, yet with our increasing knowledge of the ontogeny of various species of trilobites it is perceived that the presence, position, and nature of the eyes are points which must by no means be overlooked.

In a group such as the trilobites, the majority of which possess eyes, it is a matter of great interest to discover the meaning of their absence in certain species and genera; and as a result of recent researches on the fauna of caves and of the deep sea the conclusion

[1] *The Auk*, new ser., vol. xiii (1896), p. 63.
[2] Vol. xxxii, No. 7.

has been drawn, perhaps too hastily, that we have an example of the operation of causes similar to those which have led to the atrophy of the organs of sight in these modern forms. It is, however, possible to offer two different explanations of the phenomenon of blindness in the case of the trilobites; and it may be that the same explanation is not applicable to all. In the first place we may regard the absence of eyes as a result of functional disuse, and consequently as an adaptive character suggestive of the environment or mode of life, but of no phylogenetic importance. Owing to the attention which is now directed to the conditions of life, particularly to those of the deep sea, this view finds much favour. The alternative explanation is that the absence of eyes is a morphological feature of ontogenetic or phylogenetic significance, and consequently must have due weight attached to it in any natural system of classification. We shall see that the evidence derived from the development of various trilobites as well as of the whole group points to this being the true explanation in the majority of cases.

Nature and Position of the Eyes of Trilobites.

It should first be noticed that the visual organs found in trilobites do not all belong to the same category, for they fall into two classes. There are the so-called 'simple' eyes or ocelli, and the so-called 'compound' eyes. They are of widely different origin and are not homologous structures. It is unnecessary here to describe in detail their peculiarities and modifications, except in so far as they affect the question under consideration.

The most important differences as regards their comparative morphology which we have to remember are that the compound eyes are always borne on the free cheeks and lie on the line of the facial sutures, while the simple eyes (which may more conveniently be termed eye-spots) occur on the fixed cheeks without any connection or relation to the facial sutures. It is also possible that visual organs of the same nature as these eye-spots occur on the glabella of some forms. There is a general but superficial resemblance in the position of both these kinds of visual organs from the fact of their being on the lateral portions of the head-shield and from the presence of a pair in each case; but these are merely accidental analogies connected with their function and with bilateral symmetry.

The distribution of these two kinds of eyes is of considerable importance and interest to us in our present inquiry, and while much stress has been rightly laid on it by many palæontologists, yet it is possible to differ from their conclusions. In the case of eye-spots we find them existing as a single pair in the larvæ of some trilobites which when adult possess no visual organs (*Trinucleus*); or we find them persisting through life (*Harpes*). Certain tubercles on the fixed cheeks of other forms may have a similar function, but of this we have at present no proof; and as far as we know paired eye-spots on the fixed cheeks and compound

eyes on the free cheeks never exist together at the same time in the same individual.

It should also be noticed that the paired eye-spots are generally situated at the outer end of the so-called 'ocular ridges' which run outwards from the glabella, and though morphological structures which are apparently homologous run out in the same way as ridges to the compound eyes of certain other forms, yet we shall see that this feature is not so anomalous or difficult of explanation as it may at first appear.

We shall also perceive when we consider the families of the trilobites separately that paired eye-spots are only found amongst those of a low phylogenetic rank, and that compound eyes are characteristic of the higher and more differentiated genera.

All the principal features of those forms possessing eye-spots are of a primitive type, corresponding to those exhibited in the larval and pre-adult stages of those with compound eyes. Further remarks on this fact will be made later. It may, however, be mentioned here that since no such organs as eye-spots have been found in the larval stages of the higher forms, we must not in the light of present knowledge regard them as larval structures common to the whole group, but rather as separately developed in certain genera possessing a low phylogenetic rank more or less masked by a considerable amount of secondary specialization, just as is the case with the Metatheria in Australasia and in many smaller groups of animals. These lowly organized trilobites, while retaining certain essential primitive characters, have developed other characters analogous in function or even in structure to those present in forms much higher in the scale of evolution. Bearing this idea in mind, we may understand how the possession of visual organs, though inferior in quality to those of the higher trilobites, may have been one of the causes which enabled such a form as *Harpes* to maintain so long the struggle for existence.

That there were other factors at work than the power of sight is evident from *Trinucleus* losing its eye-spots when mature, and in one species of *Harpes* being blind. These considerations suggest that the conditions of life have left marks of their influence as well as the phylogenetic rank, and indicate that the same explanation is not applicable to every case. We must therefore examine each on its own merits.

With regard to the compound eyes of trilobites, their precise position along the line of the facial suture is subject to considerable variation, and their size in relation to that of the whole head-shield is also variable within wide limits. The very small eyes of such a genus as *Acidaspis* afford the greatest contrast to those of *Cyclopyge* (*Æglina*). But while to some extent the development and position of the compound eyes is of phylogenetic importance, yet we shall be able to show that in some cases it is certainly a secondary adaptation and apt to mislead us if regarded in any other way. We can, however, in this article only deal with the subject of the size and position of the compound eyes in so far as it concerns the inquiry into the meaning of blind trilobites.

The Development of the Compound Eyes of Trilobites.

Beecher[1] has recently brought together and admirably summarized the results of recent researches on the evolution of the head-shield in trilobites, and his conclusions are of much significance to us in our present inquiry. He emphasizes the fact that the most primitive larvæ show no eyes on the dorsal shield and have no free cheeks visible, for the latter are ventral in position and the suture is marginal or submarginal. It has, moreover, been observed that a number of genera possess in the adult condition characters which agree closely with those found in the larvæ of other and higher genera. For instance, the mature individuals of such genera as *Carausia* and *Aneucanthus* possess the principal cephalic features of the simple protaspis larval stages of the higher genera *Ptychoparia*, *Solenopleura*, and *Liostracus*; they show no eyes and no free cheeks, and thus indicate that they belong to a lower grade in the evolution of the group.[2] These primitive types predominate in the earlier Palæozoic faunas, so that their stratigraphical distribution confirms the deduction from their morphological characters. The absence of eyes, therefore, in such primitive forms as these cannot be interpreted as an adaptive character, but must be regarded as a mark of their phylogenetic rank. All the genera which are characteristic of the Cambrian faunas, and the development of which is known, pass through this blind larval stage, and a number of genera (*Agnostus*, *Microdiscus*, etc.) never pass beyond this stage, but preserve their primitive features to maturity.

The next stage in the larval history of the more advanced forms is marked by the appearance of the free cheeks on the upper surface of the head-shield as narrow marginal bands, and by the simple curved course of the facial suture which cuts them off. The genera *Ampyx* and *Conocoryphe*, s.str., exhibit these features when adult and have no compound eyes. In genera of a higher rank which possess compound eyes, the latter generally appear on the margin almost simultaneously with the free cheeks which bear them; but this simultaneous appearance is due to accelerated development and to the operation of the law of earlier inheritance. In later larval stages the free cheeks increase in width and the eyes move inwards. The successive acquisition of the foregoing characters in definite order is more or less indistinct in the higher and more specialized trilobites which attain their maximum in Post-Cambrian times, for there is a considerable acceleration of development, and their larvæ consequently exhibit characters which do not exist in the corresponding larval stages of the more ancient and primitive genera, but which only appear in the later larval or even adult stages of the latter. The two principles (1) that ontogeny furnishes the means of recognizing the true affinities of organisms, and (2) that the development of the individual correlates with the development of the group, are so firmly established that it is needless to remark

[1] Amer. Geol., vol. xvi (1895), p. 166.
[2] Beecher, Amer. Journ. Sci., vol. iii (1897), pp. 89 and 181.

further than that the above evidence from the trilobites (and much more that might be adduced) is completely in harmony with them.

We find in the trilobites a group with an uniform generalized structure and with a singularly complete geological history, and in addition to this we possess a knowledge of the ontogeny of all the principal families of different geological periods, and it is found to correspond with the phylogeny and geological succession of the members of the group. We can therefore proceed with a considerable amount of confidence in determining what are true larval and primitive characters, and in separating from them those which are of the nature of adaptations or the result of degeneration.

Characteristics of Blind Trilobites.

As may be gathered from the above remarks, it will be found that the characteristics of a large proportion of blind trilobites will be those of the earlier, lower, and more primitive families or genera which possess no compound eyes, because of their phylogenetic position. Those of this rank which possess organs of vision do so, not by virtue of their stage of evolution, but by reason of secondary specialization; and these 'eye-spots' with which they are furnished are not homologous with the compound eyes of the higher forms. In anticipation of much which is to follow we may remark that the blind higher forms, on the other hand, which have their phylogenetic position determined by their close structural resemblance to and association with forms possessing compound eyes, so that their affinities admit of no doubt, are characterized as a rule by the degeneration of the free cheek into a mere marginal band. This feature appears to indicate that the development of the compound eye and free cheek is in some way interdependent, for we find no blind form of high rank with a large triangular free cheek; the free cheek is always narrow; and the lower blind forms, as we have seen, have either no free cheek or else a very narrow marginal one. This reduction of the size of the free cheek is accompanied by the migration outwards of the facial suture and its simplification; and we remember that the marginal and simple course of the facial suture was a primitive feature. Thus the loss of the compound eyes in the higher forms is accompanied by a certain amount of reversion to primitive conditions in the head-shield. The other parts of the body are, so far as we know, unaffected, but we may reasonably assume that some modifications in the appendages took place in conjunction with the loss of eyesight, as we find to be the case in most of those modern blind crustacea which are allied to species or genera possessing eyes. Details of each individual genus of blind trilobites are given below.

The Blind Genera.

The most natural system of classification which has so far been proposed for the trilobites is that given by Beecher.[1] It has a close correspondence with that drawn up by Salter, and, being based on

[1] Beecher, Amer. Journ. Sci., vol. iii (1897), p. 183.

phylogenetic and ontogenetic principles deduced from recent investigations, is here employed. The presence of free cheeks and compound eyes and the position of the facial sutures are accorded the great phylogenetic importance which they are now ascertained to possess.

(1) Order Hypoparia.

In the order Hypoparia, which Beecher considers the lowest of the three into which the Trilobita may be divided, the three families Agnostidæ, Harpedidæ, and Trinucleidæ, and the genera which they include, show a combination of features characteristic of the earliest larval stages of higher families. Particularly is this fact apparent in the head-structure. Compound paired eyes are absent; the free cheeks form a continuous marginal ventral plate, and do not show on the upper surface of the head; the suture is ventral, marginal, or submarginal. Secondary specialization has, however, in some respects obscured these primitive features and destroyed the simplicity of their appearance. But in spite of these superinduced characters, such as the marginal fringe in *Trinucleus*, and the loss of segmentation in the glabella of some *Agnosti*, we cannot fail to perceive the general stamp of a low stage of development. Of the family Agnostidæ, the two genera *Agnostus* and *Microdiscus*, which constitute it, are blind. Matthew[1] has remarked that the genus *Agnostus* is the simplest known trilobite and shows the most perfect retention of embryonic features, and that it is especially characteristic of the early Cambrian period in America and also Europe, as the writings of Tullberg, Brögger, and Hicks have shown. Its geological distribution is thus just what we should expect from its morphological features.

In the family Harpedidæ eye-spots are frequently present on the fixed cheeks. It has been thought that eye-spots are a primitive character and of some phylogenetic importance; but from the fact that they are only found in this family, which abounds in marks of secondary specialization, and that it has not been proved that they are present even in any of the larval stages of other genera (except in *Trinucleus*, which is discussed below), it seems to me that we should regard them as special products of the extremely high degree of secondary development reached by the members of this aberrant family.

These eye-spots may reach a considerable degree of complexity in their structure, as, for instance, in *Harpes macrocephalus* (Goldf.), from the Devonian,[2] but they are in no way structures homologous to the compound eyes on the free cheeks of higher trilobites. The eye-spots are situated on the fixed cheeks at the end or along the course of the ocular ridge or eye-line which has been thought to represent the course of the optic nerve.

A structure with a similar but more extended course, and also termed the eye-line, is found in the later larval stages of some primitive Olenidæ (*Ptychoparia*, *Solenopleura*, etc.), and in these

[1] Trans. Roy. Soc. Canada, vol. v (1887), p. 160.
[2] Whidborne, Monogr. Devon. Fauna, vol. i, p. 32: Palæont. Soc., 1879.

forms it persists to an adult condition. In the later and higher genera of the Olenidæ (*Sao* and *Triarthrus*) in which it occurs it appears at an earlier larval stage owing to acceleration of development, and in *Sao* it persists throughout life. It is, however, entirely absent from every stage of all later and higher genera which have been studied.

It is interesting to find an eye-line present in some of the Conocoryphidæ, which are all devoid of eyes and are of a more primitive type than the Olenidæ, though in many respects allied to them. We are only acquainted with the later larval stages of some of the Conocoryphidæ,[1] and in these it is present. It is certainly an archaic feature, for it is characteristic of the Cambrian genera of trilobites, and four-fifths of them are said to possess it, but in later and higher genera it is absent, with the exception of the Olenidæ above mentioned. But from the fact that in the Olenidæ it makes its appearance on the dorsal shield earlier than the compound eyes on the free cheeks, and that it is also present in larval and adult stages of the more primitive Conocoryphidæ which possess no compound eyes, it cannot be maintained that its presence is consequent on the development of eyes or indicates their former existence. Moreover, from its absence in the earliest larval stages of simpler forms and in the least modified members of the Hypoparia, it seems likely to prove to be a secondary and superinduced structure, and not characteristic of the earliest and simplest stages in the phylogeny of the group. With regard to the supposed homology of the eye-line in the Olenidæ and Conocoryphidæ with the eye-line in the Harpedidæ and larval *Trinucleus* we have not sufficient evidence to draw any definite conclusion; but from the fact that in the highest forms (the Olenidæ) in which the eye-line is found it runs direct to the palpebral lobe of the compound eye and ends at the facial suture, while in the Conocoryphidæ it generally ends short of the facial suture, and branches out into a ramifying network of veins suggesting nerves (e.g. *Carausia*), and that in the Harpedidæ the eye-spot is situated upon it, though not always at its outer termination, it appears probable that this line indicates the course of a nerve or nerve-plexus along which organs of vision in some cases are developed. That its association with eye-spots and compound eyes is more or less accidental and temporary, and is not intimately bound up with its existence, is suggested—(1) by its absence in all the higher and later genera with the best developed compound eyes; (2) by its larval appearance before any organs of vision are developed; and (3) by its presence in the adult stage of the primitive blind family, the Conocoryphidæ.

It is of considerable interest to find a blind species[2] of the genus *Harpes* (*H. benignensis*, from *Dd* 1 Barr.), and its significance will be discussed later.

With regard to the origin of the eye-spots themselves, it has been explained that it does not seem possible to regard them as

[1] Matthew, Trans. Roy. Soc. Canada, vol. ii, sect. iv.
[2] Barrande, Syst. Sil. Boh., Suppl., vol. i, p. 4.

primitive or characteristic larval structures, and we cannot for the same reasons consider them as rudiments of a structure once generally present in the ancestors of the trilobites. Their exact nature in the case of *Harpes* is still not fully determined. Packard [1] does not regard them as comparable with the simple eyes or ocelli of *Limulus*, and Clarke [2] is inclined to think that they may prove to be of an aggregate character similar to the schizochroal eyes of *Phacops*. If the latter is the case we have an interesting example of parallel independent evolution. On the whole, it appears safer to consider the eye-spots in *Harpes* as the attempt on the part of a primitive type of trilobite to develop organs of vision which might enable it to hold its own in the struggle for existence with its more highly organized contemporaries, which possessed well-developed compound eyes. Similar conditions of life required similar organs of sense, and the primitive types which failed to develop them ceased to exist. Only those of which the habits removed them from the conflict, or which were able quickly to develop the necessary powers of defence or flight, managed to survive. In support of this view the long range of the genus *Harpes* may be adduced, for it appears in the Cambrian and lasts till the Devonian.

In the case of the Trinucleidæ, none of the genera in their adult condition possess organs of vision; all are blind. But some immature *Trinuclei* have eye-spots, as already mentioned. McCoy [3] was led by the occurrence of these eye-spots in certain individuals to institute a new genus which he called *Tretaspis*. It has, however, been abandoned,[4] since it is believed to be proved that it was founded on larval forms of species which in the adult condition have lost the 'ocular' tubercles. The remarks made on the eye-spots of *Harpes* apply partly to these in the larval *Trinucleus*. Thus we cannot regard them as an inherited character, nor as a primitive or larval structure common to lowly types of trilobites. It only remains to consider them as special generic or perhaps specific features, peculiar to the ontogeny of *Trinucleus* or of some of its species. They appear, therefore, to be adaptive characters, acquired to meet certain conditions of life; and in explanation of their absence in the adult we may either suppose that the adult had a different environment and mode of life which led to their degeneration, or that other organs developed which played an equivalent part, as is the case of the tactile organs of blind cave-animals. It may be mentioned that the visual function of these tubercles in the larval *Trinucleus* has never been demonstrated, and no description of lenses or visual surface has ever been published, so far as

[1] Amer. Nat. (1880), p. 503.
[2] Journ. Morph., vol. ii (1888), p. 253.
[3] Ann. Mag. Nat. Hist., vol. iv (1849), p. 410; and Brit. Pal. Foss., 1851, p. 146.
[4] Barrande, Syst. Sil. Boh., vol. i, pp. 617, 620. Nicholson and Etheridge, Mon. Silur. Foss. Girvan, fasc. 2 (1879), pp. 188–197. Beecher, Amer. Journ. Sci., vol. xlix (1895), p. 307.

I know. The general similarity, however, between the eye-line and eye-spot of *Harpes* and these structures in the larval *Trinucleus* is in favour of regarding the latter as organs of sight. From the resemblance of the tubercle on the glabella to those on the cheeks, we ought probably to regard it as possessing likewise a visual function.

The other two genera, *Ampyx* and *Dionide*, which are placed in the family Trinucleidæ, have no eyes at any stage of their development, so far as is known, and they show the typical Hypoparian characters. In neither genus have we any reason to suspect degeneration. The genus *Ampyx* displays the intermediate stage in the migration of the free cheeks from the ventral to the dorsal surface of the cephalon. Œhlert's[1] view that the marginal position of the suture of *Trinucleus*, *Ampyx*, and *Harpes* is the result of the displacement of the normal facial suture, and is therefore a secondary character and less primitive than the dorsal position, is opposed to all our knowledge of the ontogeny and phylogeny of the trilobite.

There are two genera, *Salteria* and *Endymionia*, with doubtful affinities, which are usually placed in the family Trinucleidæ. The genus *Salteria* (Wyv. Thomson)[2] possesses linear free cheeks which are supposed to bear eyes; but the evidence for their presence is weak,[3] and it is most probable that the genus is really blind. The other genus, *Endymionia* (Billings),[4] has only been found in America, and is considered to be allied to *Trinucleus* and *Ampyx*, and, so far as is known, it possesses no organs of vision.

(*To be continued.*)

IV.—On Deneholes and Bell Pits.

By T. V. Holmes, F.G.S., Hon. Sec. Anthrop. Inst.

In the Geological Magazine for July appears an article by Mr. Charles Dawson on Ancient and Modern Dene Holes. As Mr. Dawson mentions Essex deneholes, and comes to conclusions contrary to those arrived at by Mr. Cole and myself, the authors of the Report of the Essex Field Club on the Deneholes of Hangman's Wood, near Grays Thurrock,[5] I shall be glad to be allowed space

[1] D. P. Œhlert, Bull. Soc. Géol. France, vol. xxiii (1895), p. 319.
[2] Mem. Geol. Surv., dec. xi, No. 6 (1864), p. 1.
[3] Nicholson and Etheridge, Mon. Sil. Foss. Girvan, fasc. 2, p. 199.
[4] Geol. Canada: Pal. Foss. (1865), vol. i, pp. 33 and 281.

[5] Report on the Denehole Exploration at Hangman's Wood, Grays, 1884 and 1887: by T. V. Holmes and W. Cole (with three coloured plates and other illustrations).
Note on the Bones found in the Deneholes in Hangman's Wood: by E. T. Newton.
Note on a fragment of Millstone from a Denehole: by F. W. Rudler.
On Chalk Wells: by F. J. Bennett.
Note on some Pits near Chipping Norton, Oxfordshire: by H. B. Woodward.
Ensilage, or Preserving Grain in Pits: by F. C. J. Spurrell.
(*Essex Naturalist*, December, 1887.)

for a reply. For though our views do not appear to be injuriously affected by Mr. Dawson's remarks, yet as the Denehole Report is now more than ten years old it is probable that few of the readers of the GEOLOGICAL MAGAZINE have both seen and remember it. And the impression which the reader would derive from Mr. Dawson's article is, that his Bell Pit hypothesis is something quite new, and therefore unnoticed by us, whereas it was an old view before the Report was written, having been put forward by the late Roach Smith in the *Gentleman's Magazine* in 1867; and an account of workings for chalk, of the kind described by Mr. Dawson, written by Mr. F. J. Bennett, of the Geological Survey, is appended to the Denehole Report.

The name 'denehole' is said by the highest authority, that of Dr. J. A. H. Murray, to mean *dane*hole, not *den*hole, as we supposed when the Report was written. Of course, this etymological question concerns us here only as throwing light on the traditional view as to the makers of these pits. So far as the name goes it divides these pits somewhat more decidedly from primitive mines than *den*hole would do. For *dane*hole implies not merely a hiding-place, but a hiding-place from the last and best remembered of the piratical invaders of our shores, though it by no means excludes the possibility that daneholes may have been useful in the time of earlier marauders. On the other hand, as the late Roach Smith pointed out, pits for chalk, of the class described by Mr. Bennett and by Mr. Dawson, are mentioned by Pliny. It would seem, therefore, that both classes of pits, the deneholes and the bell pits, were known many centuries ago. But while collections of bell pits, such as Grime's Graves and the Pen Pits, have received various local names, the name denehole seems to have been applied only to excavations which, in the popular view, could hardly have been made for anything but hiding-places. Excavations made for the sake of the material extracted, and excavations made for the sake of the space so obtained for some domestic purpose, are both common throughout the world. Whether any given group of pits should be classed as belonging to the danehole or the bell-pit division is purely a matter of the evidence in each case, that afforded by their sites and construction being the most decisive. For gravel obtained from the site of a new town-hall is utilized as much as that from a gravel-pit on a common, though the makers of each excavation had very different purposes in view. And the mere presence or absence of human implements is, in itself, of little weight. At the present day they may usually be found most abundantly, not in ruined dwellings, but in disused gravel-pits and deserted brickyards.

The mode in which any people make excavations in a rock evidently depends partly on the position and nature of the rock, partly on the nature of the tools and appliances known to them. And we should not expect to find among a primitive people the immense variety of form in structures or excavations for different purposes which might be looked for in more advanced countries.

What we may expect to see are those differences in the nature of the site and structure which are absolutely essential, but nothing more. A primitive excavation in chalk, for example, made to obtain subterranean space, will be likely to have some superficial resemblance to another excavation of the same period made in order to procure chalk. In the case of many isolated pits the evidence may amount to so little as to prevent any decided conclusion. In such cases, however, it is as absurd to decide that they must be pits made for the sake of the material extracted as to conclude that they must have been used for domestic purposes. To us at the present day the mining explanation may seem the more probable, excavations in rocks for domestic purposes being comparatively rare. But among primitive people they are usually far more common than excavations for mining. Even in Brittany at the present time pits in the fields are used for the storage of grain. The top of the pit is covered with a layer of earth or clay to keep out the wet, and a slight mound indicates the site.[1] However, in writing of deneholes with the view of making the distinctions between them and pits for mining purposes as clear as possible, it is best to leave out of consideration excavations of doubtful affinities.

The name denehole is not confined to certain excavations in the Chalk, nor to pits with vertical entrances. A much esteemed Northern archæologist, Mr. R. O. Heslop, of Newcastle-on-Tyne, pointed out to me many years ago that deneholes exist, and are known by that name, in the county of Durham. They are mentioned in a paper read by one of the most eminent of Northumbrian antiquaries, Mr. W. H. D. Longstaff, at the Newcastle meeting of the Archæological Institute in 1852 the title of the paper being, "Durham before the Conquest." Mr. Longstaff remarks that the name 'Danes Hole' is applied to several hiding-places in the county, and that it may perhaps have originated during the warfare between Saxon and Dane, from their use as retreats during Danish incursions. He adds :—

"They are frequent in Hartness, where the struggle seems to have been most bitter, and are described as excavations in the sides of eminences, in those sides from which the most extended views might be obtained." On the map accompanying Mr. Longstaff's paper are the words, "Excavated halls called Danes Holes"; and they are shown as existing on the Magnesian Limestone of South Durham, chiefly in the neighbourhood of Embleton, six or seven miles west of Hartlepool. And in Hutchinson's History of Durham (1785), vol. iii, p. 82, there is in a note by 'Mr. Cade' the following remark: "There is a large cavity on the summit of the camp at Mainsforth which is at this day called the Danes-Hole, where there was lately dug up a pair of moose deer horns," etc. Mr. Cade thinks the site of Athelstan's victory over the Danes was about two miles from this camp, and is interested in determining

[1] Note on the use of Pits in Brittany for the Storage of Grain: by Charles Browne, M.A., Barrister-at-Law. (*Essex Naturalist*, vol. ii, 1888, p. 3.)

the spot at which the battle took place, the Danes Hole being only mentioned as having a possible bearing on that question.

If we look at a map of South Durham, the reason why Danes Holes were especially numerous about Embleton becomes obvious on the supposition that they were hiding-places from the Danes and earlier piratical marauders, but utterly unintelligible from the mining point of view. The ground slopes to the east and south-east, towards the sea and the valley of the Tees. Between Embleton and Hartlepool, the surface rock is Magnesian Limestone; south of Embleton, to Stockton-on-Tees, an equal distance away, most of the ground is occupied by Triassic beds. There must have been a natural harbour at Hartlepool one or two thousand years ago, while the Tees, three or four miles southward, offered every facility for piratical expeditions inland, to and beyond Stockton. Hence Embleton would afford hiding-places for the fishermen of Hartlepool and the inhabitants of the lower part of the Tees Valley, at a convenient distance both from the river and the sea.

Here it seems worth while to remind the reader that the southern and eastern shores of Great Britain were especially subject to piratical attacks both before and for centuries after the Roman Occupation. For the country was inhabited by scattered tribes and clans but little in the habit of acting in concert, and without any common system of defence. While during the Roman Occupation, the 'Count of the Saxon Shore' appears to have concerned himself almost wholly with the defence of the coast from the Wash southward, increased distance from the Continent forming the chief protection to the people of the Humber, the Tees and the Tyne. In short, the inhabitants of the shores of the British Isles probably suffered as much from piratical marauders before the Norman Conquest as did those living in the islands of the Mediterranean, many centuries later, from the attacks of the Barbary corsairs.

I now pass to the deneholes of Kent and Essex, more especially to those of the last-named county. Here we have three highly concentrated groups of pits, two of them at Bexley in Kent, and a third in Hangman's Wood, near Grays Thurrock, Essex. In each case there are some fifty or sixty pits, close to each other, yet without connection below the surface, except where the wall of separation has here and there been made too thin for permanent stability. The two Bexley groups, at Cavey Spring and at Stankey Wood, are about 600 yards apart. For some account of the Bexley deneholes the reader may be referred to a paper by Mr. F. C. J. Spurrell, F.G.S., which appeared in the Archæological Journal, vols. xxxviii and xxxix (1881 and 1882). Mr. Spurrell was, indeed, the first person to make any personal exploration of deneholes and to consider the probable purposes of their makers in a scientific spirit, and his paper is a storehouse of facts either about the pits themselves or the uses for which they were probably designed; his opinion being that they were mainly ancient granaries.

These three groups all occupy positions analogous to those of the Durham deneholes. In each case they are near, but not close to

the Thames, the Bexley pits at Stankey Wood (Fig. 1) and Cavey Spring (Fig. 2) being between three and four miles from the river,

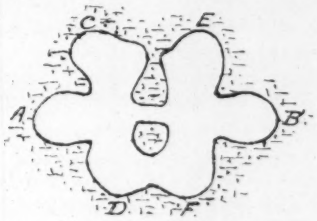


FIG. 1.—Ground-plan of Pit at Stankey Wood (west of fence), visited by the Sidcup Literary and Scientific Society, June 6th, 1885. Scale 40 feet to an inch.

Greatest length from A to B, about 52 ft. 6 in.
,, ,, ,, C to D, ,, 36 ft. 6 in.
,, ,, ,, E to F, ,, 36 ft. 6 in.
Height ... ... 18 ft. 0 in.

and the Hangman's Wood pits, at Grays, about a mile and a half (Fig. 3). But at Bexley the river Darent, a little eastward of the deneholes, would have allowed piratical craft to come a mile or two nearer these groups than the course of the Thames, apart from its

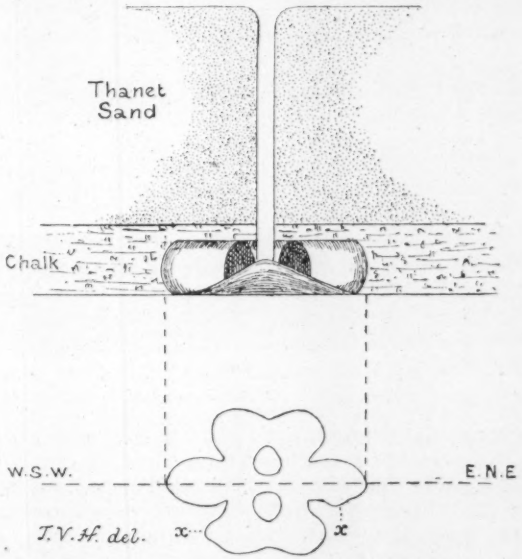


FIG. 2.—Denehole at Cavey Spring, Bexley. Scale 40 feet to an inch.

x–*x*, points at which the next pillars were being made.
Length of chamber from W.S.W. to E.N.E. ... 42 ft. 6 in.
Height ... ... 11 ft. 6 in.
Depth to bottom of chamber, from surface ... 61 ft. 6 in.
Thickness of chalk roof ... ... 3 ft. 6 in.

tributary, would allow, while at Grays the Thames has no tributary stream giving additional access to the land there. As to height above the sea, the three groups are on nearly the same level, those at Bexley being slightly over 100 feet above ordnance datum and that at Hangman's Wood a trifle below. They do not occupy ground of any natural strength, but in each case a slight valley leading up to them would allow fugitives to get to them from the borders of the Thames with but little risk of discovery.

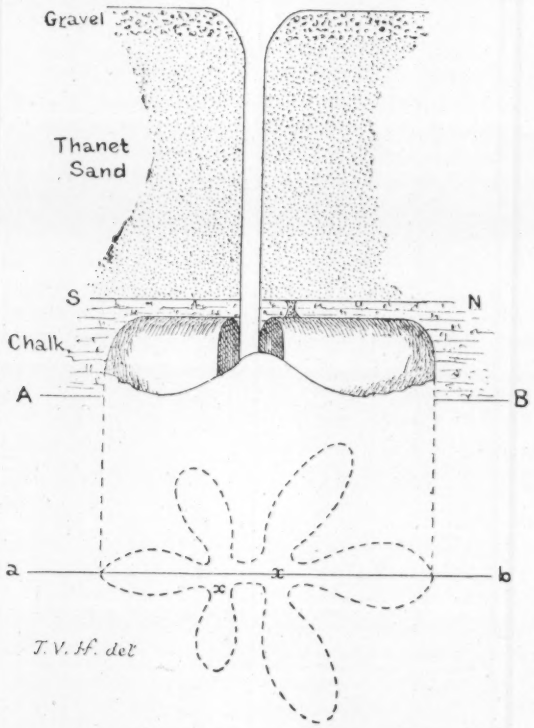


Fig. 3.—Hangman's Wood, No. 4 Pit.
Scale, 40 feet to an inch. Height of chambers, 14 to 16 feet.

These groups also resemble each other in geological position. In each case the surface bed is either Thanet Sand or gravel overlying Thanet Sand. The greater part of the shaft is in Thanet Sand and ends in the Chalk (see Figs. 2 and 3). Where there is gravel above the Thanet Sand, as at Hangman's Wood, the present mouth of the shaft is much enlarged through the tumbling in of the gravel, while where gravel is absent the Thanet Sand has stood so well that but little enlargement has taken place. The pits at Hangman's Wood are about 80 feet deep, the lowest 22 feet, or thereabouts, being Chalk. Those at Stankey Wood and Cavey Spring average from 20 to 30 feet less. The Bexley pits are also smaller in size (judging

from those entered), averaging from 40 to 50 feet in length, while at Hangman's Wood they are 70 feet long and about 18 feet high. The height of the Bexley pits is less. The thickness of the Chalk roof varies from 2 to 5 feet. At the bottom of each shaft is a conical heap, consisting of the material which has fallen down the shaft since the disuse of the pit. At Hangman's Wood we found that the lower part of this mound consisted chiefly of gravel with lumps of chalk and many very large flints. The upper part was chiefly sand. The large flints had evidently been used to 'stein' the upper part of the shaft and keep the gravel from tumbling in. It was noticeable that the Thanet Sand had stood much better than either the gravel above or the Chalk below, the footholes by means of which the shaft had, when in use, been ascended and descended, being still visible in the Thanet Sand, and still allowing ascent and descent to some extent. Most of the shafts are now filled with débris.

A most noteworthy point with regard to these groups of deneholes is, that while they are most conveniently situated for hiding-places, their position is in the highest degree absurd if they are supposed to be pits for chalk. For whereas there is plenty of bare chalk within a mile, both at Bexley and Grays, these pits have been sunk where the Chalk is covered by from 30 to 60 feet of other beds. It is said, on the other hand, that "chalk is considered to be better the deeper it lies, and the top chalk, particularly if it lies within three or four feet of the surface, very indifferent," etc. (Geol. Mag., July, 1898, p. 299). But, granting that such may be the case, that offers no explanation of the sites chosen for these groups of deneholes. It must be obvious that the course which would then commend itself to all seekers after superior chalk would be to begin operations where chalk is at the surface, make a shaft 10 to 20 feet deep, and procure chalk lying at that depth. But at Hangman's Wood, after penetrating through nearly 60 feet of gravel and sand, the excavators have taken chalk from the uppermost 20 feet.

It is of course possible that in primitive times pits close to that great highway the Thames might compete, even if the chalk were unusually deep there, with others shallower but a mile or two inland. But both at Bexley and at Grays there is plenty of bare chalk much nearer the river than the groups of deneholes.

Again, the fact that an isolated denehole might be found here and there of unusual depth, would not necessarily tell against the chalk-pit hypothesis. A farmer might naturally prefer to get chalk at a depth of 60 to 80 feet on his own land rather than procure it from some one else's pit a mile or two away. But when we are asked to believe that any people at any period deliberately concentrated their pits where they got the least return for their labour, and where there was no counterbalancing advantage whatever—as they must have done at Hangman's Wood and Bexley on the Chalk-pit hypothesis—the inference necessarily follows that the makers of the pits were lunatics.

About three-quarters of a mile west of Hangman's Wood I had the good fortune to see a real primitive pit for chalk in 1889,

a year and a half after the publication of our Denehole Report.[1] Mr. J. B. Ogle, a member of the Geologists' Association, was then good enough to tell me of some subsidences which had recently occurred between Stifford and Grays Thurrock. Close to but west of the road connecting Grays and Stifford, just where the boundary between the two parishes comes to the road from the east, were two holes, the result of a recent subsidence. They were nearly cylindrical in shape, each being between 7 and 8 feet in diameter and from 9 to 10 feet apart. Mr. Frank, residing at The Lodge, Stifford, had kindly provided a ladder, and we descended into the pit. The sides of the shaft were approximately vertical, and the section displayed consisted of—

Red clay	about 8 feet.
Yellow sand	about 2 to 3 ,,
Gravel, green-coated flints here and there	1 to 2 ,,
Chalk.	

On reaching the Chalk the pit had been at once widened out, the thickness of the Chalk roof increasing as the distance from the shaft increased. It was found possible to creep through a chalk-roofed excavation connecting the two openings, which were similar in the section they presented and in general appearance. The chalk had been worked in various directions somewhat irregularly and without any regard to permanent stability. There were many pick-marks here and there. The shape and size of the workings were much obscured by fallen material, but judging from what we saw they may have extended to a distance of 20 to 25 feet from the centre of the shaft we descended. I remarked in the *Essex Naturalist* at the time, and still think, that "the purpose of the excavators seems to have been simply the extraction of chalk for agricultural purposes." The workings had apparently been filled with vegetable refuse capped by earth, which had remained firm long after the stuff beneath had rotted away, a sudden subsidence being the result. Another subsidence had occurred in the road nearer Stifford shortly before our visit, but had naturally been filled up as soon as possible.

It would seem that these workings for chalk must be of considerable age. About 150 yards westward there is a huge open chalk-pit, which had then been disused about 30 years. And two others of much smaller size, but also disused, may be seen, a little northward and a little southward of the subsidences, east of the road. The large chalk-pit may cover perhaps 12 to 14 acres. The workings at the subsidences can hardly have been made after any of these open pits were begun, but must have been of much earlier date.

The beds above the Chalk at these workings appear to be old river-deposits. Similar beds were also visible at the northern end of the very large chalk-pit west of the road between Grays and Stifford, but much nearer Grays. The old river, which formed

[1] See Essex Naturalist, vol. iii (1889), p. 183.

them when flowing at a considerably higher level than the Mardyke at Stifford, must have had a course from north to south from Stifford to Grays, not westward from Stifford like the Mardyke of the present day.

It is easy to understand the existence of pits of this class; the Chalk, where Tertiary beds are absent, is frequently covered by irregular deposits of various kinds, and where the covering of the Chalk is thin there are usually many pipes in it. But a short shaft allows the extraction of pure chalk at a depth to which pipes seldom penetrate. In this case, no pipes having been found, opening out had been begun on reaching the Chalk. Mr. R. Meeson, at a meeting of the Archæological Institute in 1869,[1] stated that deep cavities known as 'daneholes' existed in every field in the neighbourhood of Grays Thurrock, below which there is "a substratum of Chalk." He does not give the positions of any of them, nor does he mention Hangman's Wood, the pits which he had in view being evidently such as caused these subsidences. In one case, however, he states that on opening one of them he found it full of Roman burial vases, which had been crushed by the fall of the roof.

It becomes obvious, on consideration, that we should expect to find pits of this class made to obtain chalk for purely local use in agriculture, not highly concentrated in certain spots but scattered here and there in the way mentioned by Mr. Meeson. For in Central and Northern Essex, Suffolk, and Norfolk, chalk was until lately obtained for marling the land, not directly from that formation, but from the Chalky Boulder-clay, which occupies a large proportion of the surface of those counties. Thousands of marl-pits may be seen scattered over the Eastern Counties, mostly disused. They are all open, though the uppermost two or three feet of the Boulder-clay is useless for marling, having lost the Chalk it originally contained through the action of rain.

On the other hand, where chalk is required for a broad area outside that in which it is easily obtainable, large open chalk-pits would best supply the want. The huge open chalk-pit near Stifford, west of the subsidences, must have supplied much chalk for the district northward, in which the Chalk lies deeper and deeper and there is no Chalky Boulder-clay. Immense pits like those at Grays and around Gravesend, close to the Thames, would furnish what might be best conveyed by water up the rivers of Essex and Suffolk.

Few old workings in Chalk are better known than Grime's Graves, near Brandon, on the borders of Norfolk and Suffolk, which were examined by Canon Greenwell many years ago.[2] He describes them as being 254 in number and as covering 20 to 21 acres of ground. One which he explored was 39 feet deep, the shaft being 28 feet in diameter at the mouth and gradually narrowing to a width of 12 feet at the bottom. At the surface about 13 feet of

[1] Archæological Journal, vol. xxvi, p. 191.

[2] See Journal of the Ethnological Society, new series, vol. ii (1870), p. 419.

sand covered the Chalk. All the pits were filled up to within 4 feet of the surface. "This seems to have been done," he says, "by throwing into an open shaft the waste materials taken out of one or more pits in course of being excavated." The object in this case was the extraction of flint; that from a band at the bottom being of specially good quality for the manufacture of implements. This band being reached, the flint on the floor was removed, and galleries about 3 feet high and from 4 feet to 7 feet wide were driven in various directions, and the flint in them extracted till the shafts were more or less connected together by means of these galleries.

Similar workings in Chalk for flint were those at Cissbury, near Worthing, which have been explored by Lieut.-General Pitt-Rivers, Mr. Park Harrison, and others. Mr. Spurrell, in the paper which I have already mentioned, says that at Cissbury the shafts varied in depth from 17 feet to 42 feet. The width of the simplest shaft decreased from 18 feet at the top to 4 ft. 6 in. at the bottom, but other shafts were sunk with terraces and burrows at various depths as seams of flint were cleared out and followed.

Passing from the Chalk, we have mines of a similar kind in the well-known Pen Pits, near Stourhead, on the borders of Wiltshire and Somerset. Here on a promontory of a plateau of Upper Greensand, there are hundreds of cup-shaped hollows varying in diameter from 10 to 20 feet and in depth from 5 to 10 feet. Lieut.-General Pitt-Rivers examined some of them, which he found had been used as mines, to a band of stone lying a few feet below the surface, which was suitable for querns, etc. It had been thought by an eminent antiquary that the Pen Pits were the site of an ancient British village. But against this view there is not only the fact that stone has certainly been procured from these pits, but there is another point which has hardly received the attention it deserves. Similar workings are visible on the same horizon on the other side of a valley too broad and deep to allow of all of them having formed part of the same village.

The pits in Purbeck stone, described by Mr. Dawson in the Geological Magazine for July, seem to have a strong general resemblance to the workings in Chalk for flint at Cissbury and Grime's Graves, and to the Pen Pits of Stourhead. In all these cases the concentration of the pits is a natural result of the fact that whether a narrow band of stone or a particular seam of flint was required, the seekers have felt it necessary to keep in touch with it. In each instance we have a vertical shaft of no great depth but of considerable breadth, from the bottom of which a widening out takes place, the details varying with the stability of the rock, the proportion required for removal, etc. At Grime's Graves galleries connect the shafts; in no case can this be objectionable in mines except on the score of stability. And at Grime's Graves, as in Mr. Dawson's Purbeck pits, we find that the débris from a new shaft goes to fill up an old one. This of course becomes necessary when so small a proportion of the rock in which the excavations are

made is required at the surface as in these examples. But whatever may be the differences in detail between the workings in Chalk for flint at Grime's Graves and Cissbury, the Pen Pits or the Brightling Pits, they are all palpably mines, and suggest no other explanation to those acquainted with their structure.

In the case of the deneholes of Stankey Wood and Cavey Spring, Bexley, and of those of Hangman's Wood, Grays, the fundamental differences between them and mines of the bell-pit class reveal themselves simply in proportion to the closeness of the examination they receive. We have already seen that the spots chosen as the sites of each of these three collections of pits are well suited for hiding-places, but the worst possible situations for chalk-mines, being where the Chalk is from 30 to 60 feet below the surface, though there is plenty of bare chalk in each case within a mile. Now though single pits might easily be of unusual depth without any significance attaching thereto, no people ever deliberately concentrated their pits where they received the least return for their labour —as they must have done at Grays and Bexley on the Chalk-pit hypothesis. And there is no imaginable counterbalancing advantage in their sites, from the Chalk-pit standpoint.

Passing from the sites to the structure of these three collections of deneholes, the essential differences are these:—The shafts of the bell-pit groups are necessarily broad to allow of the passage upwards of a considerable amount of material at a single haul, as shown by Mr. Dawson in his section of a Brightling pit. The shafts of these groups of deneholes are, on the other hand, extremely narrow. In some cases at Hangman's Wood we found them, in places, with a diameter still under three feet, and with the footholes at the sides so little obliterated that Mr. Miller Christy ascended and descended several feet, in the Thanet Sand part of one shaft, by their aid. The Gravel above and the Chalk below have not weathered so well as the Thanet Sand, but when in use the shaft throughout must have been somewhat narrower than the narrowest part of a shaft to-day. The length (80 feet) and narrowness of the Hangman's Wood shafts were indeed as unfavourable to the operations directed by Mr. Cole and myself, as they would have been to seekers after chalk for agricultural purposes. For when we considered how we might remove from certain chambers the débris resulting from the weathering of the shaft during centuries of disuse, it became obvious that the length and narrowness of the shafts were fatal, on account of the great expense involved, to any project for removing it to the surface.

Then, at the base of the denehole shaft, another contrast presents itself. The bell pit simply widens out for a certain distance round the shaft, as indicated in Mr. Dewson's plan and section of the Brightling pit. The 'ancient Essex denehole,' on the same page, however, gives an inaccurate notion of the plan of a denehole near the shaft, as may be seen on comparing it with the ground-plan of the Hangman's Wood pits visited, given in our Denehole Report. As I have already stated, the Chalk at the base of the shafts has

by no means weathered as well as the Thanet Sand, and in many cases the passage from the base of the shaft to the chambers is much broader than it originally was. But even now an inspection of the ground-plan shows that in none of them is there any widening out from the base of the shaft like that of the Brightling pit, and that in almost all of them the passage at the base of the shaft is very decidedly narrower than any other part of the pit. It must have been still narrower, at one time, to allow of the continuation of the footholes to the floor of the pit. Then, those deneholes which we were able to enter, though their makers had apparently been restricted to a greatest length of 70 feet, showed certain differences in plan and development such as might be looked for if each denehole were a family hiding-place and storehouse, but unintelligible on the supposition that they were originally pits for chalk.[1] And the care taken at the surface to preserve the flattened contour characteristic of a gravel plateau, is a care that would be simply silly were these deneholes pits for chalk, though absolutely necessary if they were hiding-places and secret storehouses.

I might enter into further details, but trust that enough has been said to make it evident that Deneholes and Bell Pits belong to totally different classes of excavations, the resemblances between them being superficial and the differences fundamental. In short, Deneholes were made for the sake of the excavation, and Bell Pits for the sake of the material extracted from the excavation. The archæological evidence bearing on deneholes ancient and modern and the uses to which they have been put, though of great interest, would seem out of place in the GEOLOGICAL MAGAZINE.

NOTICES OF MEMOIRS.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.
BRISTOL, September 8, 1898.

ADDRESS TO THE GEOLOGICAL SECTION, BY W. H. HUDLESTON, M.A., F.R.S., President of the Section.

Introductory.

ABOUT this time last year British geologists were scattered over no inconsiderable portion of the Northern Hemisphere, partly in consequence of the International Geological Congress at St. Petersburg and partly owing to the meeting of the British Association at Toronto. From the shores of the Pacific at Vancouver, on the one hand, to the highlands of Armenia on the other, there were parties engaged in the investigation of some of the grandest physical features of the earth's surface.

The geologists in Canada were especially favoured in the matter of excursions. Everything on the American continent is so big that

[1] It is worth adding that no attempt had been made to extract flint from a prominent band seen in each pit at Hangman's Wood 4 to 6 feet above the floor, or from any other band.

a considerable amount of locomotion is required to enable visitors to realize the more prominent facts. If there be no great variety of formation in Canada, yet the Alpha and Omega of the geological scale are there most fully represented, from the great Laurentian complex at the base to the amazing evidences of glacial action, in a country where it is possible to travel for a whole day without once quitting a glaciated surface. But Russia presented equal attractions, and in Finland almost identical conditions were observed, viz. glacial deposits on Archæan rocks. The great central plain of Russia, too, with its ample Mesozoic deposits often abounding in fossils, offered attractions which to some may have been stronger than the mineral riches of the Urals or the striking scenery of the Caucasus.

It seems almost incredible, even in this age of extraordinary locomotion, that scenes so wide apart were visited by British geologists last autumn. This year we are more domestic in our arrangements, and Section C finds its tent pitched once more on the classic banks of the Bristol Avon, and in that part of England which has no small claim to be regarded as the cradle of English geology. But we may go a step further. For if the strata observed by William Smith during the six years' cutting of the Somersetshire coal-canal imprinted their lessons on his receptive mind, it is also equally true that Devonshire, Cornwall, and West Somerset first attracted the attention of the "Ordnance Geological Survey." And thus it comes to pass that the region which lies between the Bristol Channel and the English Channel claims the respect of geologists in all parts of the world, not only as the birthplace of stratigraphical palæontology, but also as the original home of systematic geological survey.

The city of Bristol lies on the confines of this region, where it shades off north-westwards into the Palæozoics of Wales, and north-eastwards into the Mesozoics of the Midland Counties. There are probably few districts which display an equal amount of variety within a limited circumference. The development of the various formations was excellently pourtrayed by Dr. Wright, when he occupied this chair twenty-three years ago—so well indeed, that his address might serve as a textbook on the geology of the district. In the following year (1876) there appeared the Survey Memoir on the Geology of East Somerset and the Bristol Coalfield, by Mr. H. B. Woodward, who has since contributed important memoirs on the Jurassic rocks of Britain, which are so largely developed in Somerset and the adjacent counties. Since that date many papers also have appeared in various journals, and some of these, as might be expected, give new and perhaps more accurate interpretations of phenomena previously described. In addition to this, portions of the south-west of England have been geologically re-surveyed, and in some cases new maps have been published.

I would call especial attention to the Survey Map on the scale of four miles to the inch, known as the "Index Map," which has recently been issued. Sheet 11 includes this particular district; but

if a portion of Sheet 2 is tacked on to its southern border we obtain a block of country about 120 miles square, which has not its equal for variety of geological formation in any part of the world within the same space. If Europe is to be regarded as presenting a geological epitome of our globe, and if Great Britain be an epitome of Europe, then, without doubt, this particular block of the south-west, which has Bath for its more exact centre, with a radius (say) of fifty miles, may be said to contain almost everything to be found on the geological scale, except the very oldest and the very youngest rocks; while east of the Severn and south of the Bristol Channel true Boulder-clay is rare or absent.

It may be convenient to consider a few points which have arisen of late years in connection with the geology of portions of the district now under consideration.

Palæozoic.

If we omit the Silurian inlier at Tortworth, the geological history of the country, more immediately round Bristol, may be said to commence with the Old Red Sandstone, whose relations with the Devonian towards the south-west have always presented some difficulty. And this difficulty is accentuated by doubts as to the true Devonian sequence in West Somerset and North Devon. Ever since the days of Jukes that region has been fruitful in what I must continue to regard as heresy until the objectors have really established the points for which they are contending. The uncertainty is to be regretted, since it is through these beds of West Somerset that the system is to be made to fit in with the several members of the Old Red Sandstone.

There is a mystery underlying the great alluvial flats of Bridgewater which affects more than one formation; so much so that one cannot avoid asking why there should be Old Red Sandstone in the Mendips and Devonian in the Quantocks. The line which separates the Old Red Sandstone of South Wales and the Mendips from the West Somerset type of Devonian lies here concealed. I have already suggested[1] that, if we regard the Old Red Sandstone of South Wales as an inshore deposit over an area which was deluged with fresh water off the land, we can believe that further out to sea, in a south-westerly direction, the conditions were favourable for the development of a moderate amount of marine mollusca. This view not only does away with the necessity for a barrier, but it also, in a general sense, suggests a kind of gradation between the Old Red and Devonian deposits. Mr. Ussher, whose practical acquaintance with this region dates from a long period, stated a few years ago that, "As far as Great Britain is concerned, the true connections of the Old Red Sandstone beds with their marine Devonian equivalents have yet to be carefully worked out on the ground."[2] I am not aware that further progress has been made in this direction.

[1] Trans. Devonsh. Assoc., vol. xxi (1889), p. 45.

[2] "Prospects of obtaining Coal by boring South of the Mendips": Proc. Som. Nat. Soc., vol. xxxvi (1891), pt. 2, p. 104.

The Carboniferous Limestone of the Bristol area has attracted the attention of so many distinguished geologists that its palæontology and general features are tolerably familiar. Of late years we owe some interesting petrographic details to Mr. Wethered. The varying thickness of the Carboniferous Limestone and also of the Millstone Grit in this part of England is noteworthy. If we follow the Carboniferous Limestone in a south-westerly direction, across the mysterious Bridgewater flats, a change is already noted in the case of the Cannington Park limestone, which was the subject of so much discussion in former years. Referring to this, Mr. Handel Cossham [1] was so sanguine as to believe that its identification with the Carboniferous Limestone would have the effect of extending the Bristol Coalfield thirteen miles south of the Mendips. However this may be, all further traces of Carboniferous rocks fail at this point. After crossing the Vale of Taunton, when next we meet with them in the Bampton district, the Culm-measure type, with its peculiar basal limestones, is already in full force.

In the new "Index Map" the Culm-measures are placed at the base of the Carboniferous series—below the Carboniferous Limestone. It is no part of my purpose to attempt any precise correlation, but I would point out the somewhat singular circumstance that the change to Culm rock occurs only a few miles to the south-west of the line where, in the previous system, we have already seen that the Old Red Sandstone changes into the Devonian. This curious coincidence may be wholly accidental, or it may be the result of some physical feature now concealed by overlying formations.

Since 1895 a new light has been thrown on the lower Culm-measures by the discovery of a well-marked horizon of Radiolarian rocks. One result of the important paper of Messrs. Hinde and Fox has been to alter materially our views as to the physical conditions accompanying the deposition of a portion of the Culm-measures. The palæontology leads the authors to conclude [2] that "the Lower *Posidonomya*- and Waddon Barton Beds are the representatives and equivalents of the Carboniferous Limestone in other portions of the British Isles; not, however, in the at present generally understood sense that they are a shallow-water facies of the presumed deeper-water Carboniferous Limestones, but altogether the reverse, that they are the deep-water representatives of the shallower-formed calcareous deposits to the north of them. . . . . The picture that we [Messrs. Hinde and Fox] can now draw of this period is that while the massive deposits of the Carboniferous Limestone—formed of the skeletons of calcareous organisms—were in the process of growth in the seas to the north [i.e. in the Mendip area and elsewhere] there existed to the south-west a deeper ocean in which siliceous organisms predominated and formed these siliceous radiolarian rocks."

This is probably a correct view of the case, but one cannot help wondering that the ocean currents and other causes did not effect

[1] Proc. Cottes. Club, vol. viii (1881–2), p. 20 et seq.
[2] Quart. Journ. Geol. Soc., vol. li (1895), p. 662.

a greater amount of commingling of the elements than seems to have taken place. As a practical result, this discovery of a Radiolarian horizon in the Culm-measures has been of service in enabling surveyors to discriminate between Devonian and Carboniferous in the very obscure area on the other side of Dartmoor. This, I ventured to predict, would be the case when the paper was read before the Geological Society.

The principal features of the Bristol Coalfield are too well known to call for many remarks. It would seem that the Pennant rock was formerly regarded as Millstone Grit, until Mr. Handel Cossham, in 1864, pointed out the mistake. Mr. Wethered gave a good description of the Pennant in his paper on the Fossil Flora of the Bristol Coalfield.[1] It might seem almost unnecessary to refer to the existence of such a well-known formation as the Pennant, but for the fact that in a recent scheme of the Carboniferous sequence in Somersetshire the Pennant rock was wholly omitted.

The interest now shifts from the almost continuous deposition of the later Palæozoics, in one great geosynclinal depression, to an entirely different class of phenomena. Nowhere, perhaps, are the effects of the Post-Carboniferous interval better exhibited than in those parts of the south-west of England where Tertiary denudation has removed the Mesozoic deposits. Here we perceive some of the effects of the great foliations which terminated the Palæozoic epoch in this part of the world. The immense amount of marine denudation which characterizes this stage is particularly obvious in the anticlinals, which were the first to suffer, as they came under the planing action of the sea.

Attention may be drawn to a peculiarity which has no doubt been observed by many persons who have studied a map of the Bristol and Somerset Coalfield. It will be seen that the strike of the Coal-measures is widely different on either side of a line which may be drawn through Mangotsfield to a point north of Bristol. The beds north of this line have for the most part a meridional strike, nearly parallel with the present Cotteswold escarpment; south of this line the strike is mainly east and west, though much curved in the neighbourhood of Radstock and the flanks of the Mendips. Of course, this is only part of an extensive change in the direction of flexure, much of which is still hidden under Mesozoic rocks. Mr. Ussher, in the paper previously quoted, tells us that the line of change of strike may be traced in the general mass of the Palæozoic rocks, from near Brecon in South Wales to the neighbourhood of Frome. This means that within the Bristol district two distinct systems of flexure must have impinged on each other in Post-Carboniferous times. Have we not here, then, another instance of extraordinary change within the limits of our area? This time it is not a mere change in the nature of a deposit, like that of the Old Red Sandstone into the Devonian, or of the Carboniferous Limestone into the Culm-rock, but a change in the direction of the elevatory

[1] Proc. Cottes. Club, vol. vii (1878), p. 73.

forces, which had made its mark on the structure of our Island even at that early date.

At this point I ought to quit the Palæozoics; but there is just one subject of interest which claims a momentary attention, viz., the probability of finding workable coal east of the proved Somersetshire field. I avoid the question of coal south of the Mendips as being too speculative, on account of the chances of deterioration of the Coal-measures in that direction. But in view of the forthcoming meeting of the British Association at Dover, the question of finding coal to the eastward of Bath becomes a specially interesting subject for discussion. It is also a matter of some consequence whether the hidden basin or basins belong to the meridional or to the east and west system of flexures. The latter is most likely to be the case.[1] The Vale of Pewsey has been mentioned as a suitable locality for boring along the line of the recognized axis.

But prospectors should bear in mind the warning of Ramsay, that the basins containing coal are but few in comparison with the number of basins throughout the Palæozoic rocks. No doubt the line indicated is more favourably situated for coal-exploration than the Eastern Counties; where, for instance, the Coal Boring and Development Company has lately gone into liquidation. The unsuitability of East Anglia as a field for coal-prospecting was insisted on in my second anniversary address to the Geological Society,[2] and the results seem to have been very much what might have been expected. If coal is to be found beneath the Secondary rocks the line of search should be carried through the counties of Kent, Surrey, Berkshire, and Wiltshire, though the three latter counties have hitherto been content to leave their underground riches unexplored. The Kent Coal Exploration Company is doing some good work with a reasonable chance of success; though if they wish to find coal sufficiently near the surface they had better adhere as much as possible to the line of the North Downs, since operations on the Sussex side are only too likely to be within the influence of the Kimmeridgian gulf, which was proved to exist at Battle (Netherfield). Mr. Etheridge. I hope, will have something to tell us as to the progress of the Kent Collieries Corporation, who now carry on the work at Dover.

Secondary Mesozoic Rocks.

Commencing a totally different subject, I must now direct attention to the 'red beds' and associated breccias so characteristic of Eastern Devonshire. These rest in complete discordance on the flanks of the Palæozoic highlands, and must be regarded as forming the base of the Secondary rocks of that district.

[1] The boring at Burford, where coal was found at a depth of 1,100 feet, below a surface of Bathonian beds, at a point thirty-five miles E.N.E. of the extreme end of the Bristol Coalfield at Wickwar, is not included in this category; since it must belong to the meridional system, and is altogether outside the prolongation of the axis of Artois.

[2] Quart. Journ. Geol. Soc., vol. L (1894), p. 70.

By the Geological Survey this series has hitherto been mapped as Trias, but in the new "Index Map" they are coloured as Permian. There is no palæontological evidence which would connect them with the fossiliferous Permians, usually regarded as of Palæozoic age, but it has been evident for some time past that opinion was inclining to revert to the views of Murchison and the older geologists, more especially as to the position of the breccias so largely charged with volcanic rocks. The subject was dealt with by Sir A. Geikie in his address to the Geological Society, where he speaks of some of these rocks as presenting the closest resemblance to those of the Permian basins of Ayrshire and Nithsdale.[1]

One difficulty which presented itself to the Devonshire geologists in accepting the Permian age of the 'red beds' was, that the whole of the lower Secondary rocks appeared as an indivisible sequence, proved by its fossils to be of Keuper age at one end, and therefore inferentially of Keuper age at the other. Dr. Irving, however, considered that at the base of the Budleigh Salterton pebble-bed there is a physical break of as much significance as that between the Permian and Trias of the Midlands. In the marls which underlie this pebble-bed he recognized a strong resemblance to the Permian marls of Warwickshire and Nottinghamshire; and Professor Hull, who had been studying the sections east of Exmouth about the same time, ultimately acceded to this view.[2] Its acceptance by the Survey thus throws all the Exmouth beds into the Permian; and that formation, according to the new reading, has an outcrop of some 35 miles from the shores of the English Channel to within 3 miles of Bridgewater Bay. The fertility of these red clays, loams, and marls has long been recognized by agriculturists, and it is not improbable that the abundance of contemporaneous volcanic material may in some measure have contributed to this result.

In conformity with the new mapping, the Budleigh Salterton pebble-bed and its equivalents to the northwards are accepted as of Bunter age, and thus constitute the base of the Trias in the south-west. Like most pebble-beds, they are irregularly developed between the Permians and a strip of reddish sandstone (coloured as Keuper), which runs up from the mouth of the Otter to within a short distance of Bridgewater Bay. The materials of the pebble-beds are not of local origin, like so much of the breccia at the base of the Permian. The general resemblance, both as regards scenery and composition, to the Bunter conglomerate of Cannock Chase has been pointed out by Professor Bonney, who seems prepared to endorse the recognition of the Budleigh Salterton pebble-bed as a Bunter conglomerate. He was not impressed by any marked unconformity with the underlying series. To some extent we may accept this view, since whatever may be the age of the Devonshire

[1] Quart. Journ. Geol. Soc., vol. xlviii (1892), p. 161.

[2] Cf. Irving, Quart. Journ. Geol. Soc., vols. xliv (1888), p. 149; xlviii (1892), p. 68; and xlix (1893), p. 79; and Hull, op. cit., vol. xlviii (1892), p. 60.

breccias and 'red beds,' they, in common with the Trias, must have been deposited under fairly similar physical conditions in a sort of Permo-Triassic lake basin.

The bulk of the Trias, including the Dolomitic Conglomerate of the Bristol district, is still regarded as of Keuper age, though it is now admitted, as insisted on by Mr. Sanders years ago, that the Dolomitic Conglomerate does not necessarily occupy the base of the Keuper, but is mainly a deposit of hill-talus, which has been incorporated with the finer deposits of the old Triassic lake as the several Palæozoic islands gradually became submerged. The great blocks which fell from the old cliffs were formerly regarded as proofs of glacial agency, and there are persons who still believe, more especially with respect to the Permian breccias, that such rocks are indicative of a glacial origin.

In the "Index Map" the Dolomitic Conglomerate and the Red Marl are thus included under the same symbol and colour. But this is also made to include the Rhætic—an arrangement which is hardly in accordance with the facts observed in the Bristol area. On a small-scale map so narrow an outcrop as that of the Rhætic could hardly be shown; yet its affinities are probably with the Lower Lias rather than with the Trias. The late Edward Wilson, whose recent death we all deplore, in his paper on the Rhætic rocks at Totterdown,[1] showed most clearly that the 'Tea-green marls,' which had previously been associated with the Rhætic, represent an upward extension of the Red Marls of the Trias, in which the iron had suffered reduction; although there are indications of a change of conditions having set in before the deposition of the Rhætics. The black Rhætic shales which succeed usually have a sharp and well-defined base in a bone-bed with quartz pebbles, etc., indicating a sudden change of physical conditions, though perhaps no marked unconformity. In the South Wales district the Rhætic limestones are said to be largely of organic origin and, in addition to a Rhætic fauna, to abound in the lamellibranchs so plentiful in the lowest Lias limestones.[2]

The late Charles Moore always deplored the comparative poverty of the Trias in fossils. In his last communication to the Geological Society,[3] he set himself to describe certain abnormal deposits about Bristol, and to institute a comparison with the region of the Mendips. He then suggested, on the faith of a sketch by Mr. Sanders, that the famous Durdham Down deposit, already inaccessible, might have been a fissure-deposit in the Carboniferous Limestone like those at Holwell. He also stated that at one time he had been inclined to regard the Reptilian deposit on Durdham Down as of Rhætic age; but the discovery of teeth of *Thecodontosaurus*, identical with those of Bristol, in a Keuper Marl deposit near Taunton, induced him to refer the Durdham Down deposit to the middle of the Upper Keuper. He had arrived at the conclusion

[1] Quart. Journ. Geol. Soc., vol. xlvii (1891), p. 545.
[2] Ann. Rep Geol. Survey for 1896, p. 67 (1897).
[3] Quart. Journ. Geol. Soc., vol. xxxvii (1881), p. 67.

that the same genera of vertebrata are found in the Keuper and Rhætic beds, though the species, with few exceptions, are quite distinct.

But it is with the Lias that the name of Charles Moore is most intimately associated. Time does not permit me to do more than allude to the wonderful collections of Rhætic and Liassic fossils made by him from the fissure-veins of the Carboniferous Limestone, or of the treasures which are stored in the Bath Museum. There never was a more enthusiastic palæontologist, and nothing pleased him better than to exhibit the fossilized stomach of an *Ichthyosaurus*, stained by the ink-bag of the cuttle-fish, on which it had been feeding, or some similar palæontological curiosity. Everyone here knows how deeply the West of England is indebted to Charles Moore for his unceasing researches, and I have been thus particular in alluding to them because it was under his auspices that I first became acquainted with the geology of this part of the country just thirty years ago.

Amongst more recent work in the Rhætic and Lias I might mention papers by Mr. H. B. Woodward and Mr. Beeby Thompson, each in explanation of the arborescent figures in the Cotham Marble. The latter revives an old idea with modifications, and his theory certainly seems plausible. Mr. H. B. Woodward's Memoir of 1893 does full justice to the Lias of this district, and much original matter is introduced.

It is, however, in the Inferior Oolite that the most important interpretations have to be recorded since the days when Dr. Wright and Professor J. Buckman endeavoured to correlate the development of the series in the Cotteswolds with that in Dorset. To this subject I alluded at considerable length in my address to the Geological Society in 1893, pointing out how much we owed in recent years to the late Mr. Witchell and to Mr. S. S. Buckman. In the following year appeared Mr. H. B. Woodward's Memoir on the Lower Oolitic Rocks of England ("Jurassic Rocks of Britain," vol. iv), wherein he did full justice to the work of previous observers. Meantime Mr. Buckman has not been idle, and his paper on the Bajocian of the Sherborne district[1] marks the commencement of a new era, where the importance of minute chronological subdivisions, based upon the prevailing ammonites, is insisted on with much emphasis. This system he considers to be almost as true for the Inferior Oolite as for the Lias.

There can be no doubt that its application has enabled Mr. Buckman to effect satisfactory correlations between the very different deposits of the Cotteswolds and those of Dorset and Somerset. In subsequent papers also he brings out an important physical feature, viz., the amount of contemporaneous denudation which has affected deposits of Inferior Oolite age in this country. This serves in part to explain the absence of well-known beds in certain areas. For instance, in the Cotteswolds contemporaneous

[1] Quart. Journ. Geol. Soc., vol. xlix (1893), p. 479.

erosion has, prior to the deposition of the Upper *Trigonia*-grit, cut right through the intervening beds, so as to produce in the neighbourhood of Birdlip a shelving trough six miles wide and about 30 feet deep. Thus the extensively recognized overlap of the *Parkinsoni*-zone is accentuated in many places.

We have a further instance of good work in the case of Dundry Hill. An inspection of the 1-inch Survey map would lead one to suppose that the Inferior Oolite there rests directly on the Lower Lias. Recently, owing to the investigations of Messrs. Buckman and Wilson,[1] this apparent anomaly has been removed, whilst beds of Middle and Upper Lias age and even Midford Sands have been recognized. In this way the authors claim to have reduced the thickness assigned to the Inferior Oolite on Dundry Hill by about 100 feet. In the paper above quoted the vicissitudes and faunal history of the Inferior Oolite from the *opalinus*-zone to the *Parkinsoni*-zone inclusive are shown with much detail; whilst the position of the chief fossil-bed in time and place has been well established. The general resemblance of the Dundry fossils to those of Oborne, which I could not fail to notice in working out the Gasteropoda of the Inferior Oolite, now admits of explanation. Although the quondam *Humphriesianus*-zone is richly represented, yet the particular *Humphriesianum*-hemera is held to be absent at Dundry. But if there be a *Sowerbyi*-bed anywhere it should serve to connect these two localities, where, according to Mr. Buckman's phraseology, the principal zoological phenomenon is the acme and paracme of *Sonninin*æ.

Mr. Buckman, as we have seen, is no longer satisfied with the old-fashioned threefold division of the Inferior Oolite, and his time-table includes at least a dozen hemeræ, with prospect of increase. Granting that it would have been difficult to solve the Dundry problem without a detailed knowledge of ammonite horizons, there arises the question as to the utility of such minute subdivisions for the purposes of general classification. Mr. Buckman has earned the right to put forward, if he pleases, the several stratigraphical rearrangements in which from time to time he indulges. The Inferior Oolite has been his especial playground, and, as the kaleidoscope revolves, this formation is perpetually made to assume different proportions, even to the verge of extinction. But this practice is not without its disadvantages; whilst the invention of new names tends to clog the memory, and the novel use of old ones is apt to produce confusion.

We have not quite finished with Dundry yet, since that classic hill serves to illustrate in Mesozoic times a peculiarity of which I have already pointed out two notable instances in this district, where an abrupt and seemingly unaccountable difference is observed in beds which are approximately synchronous. The problem to be solved is this—Why does the fossiliferous portion of the Inferior

[1] Quart. Journ. Geol. Soc., vol. lii (1896), p. 669. Cf. also Proc. Brist. Nat. Soc., vol. viii (1897), pt. 2, p. 188.

Oolite on Dundry Hill resemble that of the neighbourhood of Sherborne, both in lithology and fossils, rather than that of the Cotteswolds, only a few miles distant?

Nine years ago Mr. Buckman offered an ingenious solution of this difficulty;[1] although his recent investigations at Dundry, and especially his appreciation of the effects of contemporaneous erosion, may have caused him to alter his views. Like most people who wish to account for strong local differences, he placed a barrier of Palæozoic rocks between Dundry and the southern prolongation of the Cotteswold escarpment. At that time it was not fully realized that the Inferior Oolite in the Bath district is, for the most part, limited to the *Parkinsoni*-zone, so that the comparison was really being made between beds of different age as well as different physical conditions. The question resolves itself into one of local details, which are not suited for a general address. Still, I think it may be taken for granted that, notwithstanding the east-and-west barrier of the Mendip range, which acted effectually previously to the *Parkinsoni*-overlap, there was in some way a communication by sea between Dundry and Dorsetshire, more especially during the *Sowerbyi*-stage, and this most probably was effected round the western flank of the Mendips. Thus, without acceding to the necessity for a barrier facing the southern Cotteswolds, we may readily believe that much of the Inferior Oolite of Dundry Hill is to be regarded as an outlying deposit of the Anglo-Norman basin. If this be so, it is difficult to avoid the conclusion that the low-lying area of the Bridgewater flats was, during part of the Inferior Oolite period, occupied by a sea which was continuous from Sherborne to Dundry, and that, although the barrier of the Mendips was interposed, communication was effected round the west flank of that chain. This would make a portion of the Bristol Channel a very ancient feature.

We must now take a wide leap in time, passing over all the rest of the Jurassics, and just glancing at the Upper Cretaceous system, which reposes on the planed-down surface of the older Secondary rocks. The remarkable double unconformity is nowhere better shown than in the south-west of England. Some of the movements of the older Secondary rocks, prior to the great revolution which brought the waters of the Cretaceous sea over this region, have been successfully localized by Mr. Strahan, more especially in the south of Dorset.

Owing to Tertiary denudation the Chalk in this immediate district has been removed, and we have no means of judging the relations of the Cretaceous deposits to the Palæozoic rocks of Wales. If we may judge by results recently recorded from Devonshire[2] the Lower Chalk especially undergoes important changes as it is traced westwards, and, generally speaking, terrigenous deposits seem more abundant in this direction. At the

[1] Proc. Cottes. Club, vol. ix (1890), p. 374.
[2] Cf. Jukes-Browne and Hill, Quart. Journ. Geol. Soc., vol. lii (1896), p. 99.

same time the more truly oceanic deposits, such as the Upper Chalk, appear to be thinning. As regards the possible depths of the Cretaceous sea at certain periods, we are supplied with some interesting material in Mr. Wood's two papers on the Chalk Rock,[1] which has been found especially rich in Gasteropoda at Cuckhamsley, near Wantage.

Tertiary, Pleistocene, and Recent.

Although the Tertiaries of the Hampshire basins are within the "Index Map" which we have been considering, they may be regarded as beyond our sphere. Some of the gravels of Dorsetshire, which have gone under the name of plateau gravels, are held by Mr. Clement Reid to be of Bagshot age. Many of the higher hill gravels most likely date back to the Pliocene, and even further, and represent a curious succession of changes, brought about by meteoric agencies, where the valley-flat of one period, with its accumulated shingle, becomes the plateau of another period—an endless succession of revolutions further complicated by the Pleistocene Cold Period, which corresponds to the great Ice Age of the north.

In the more immediate neighbourhood of Bristol, since some date in Middle Tertiary time, the process of earth-sculpture, besides laying bare a considerable amount of Palæozoic rock, has produced both the Jurassic and Cretaceous escarpments as well as the numerous gorges which add so much to the interest of the scenery. These phenomena have been well described by Professor Sollas,[2] when he directed an excursion of the Geologists' Association in 1880. Should any student wish to know the origin of the gorge of the Avon at Clifton, for instance, he will find in the Report an excellent explanation of the apparent anomaly of a river which has been at the trouble of sawing a passage through the hard limestone, when it might have taken what now seems a much easier route to the sea by way of Nailsea.

The origin and date of the Severn Valley is a still bigger question, and this was broached by Ramsay, some five-and-twenty years ago, in a suggestive paper on the River-courses of England and Wales.[3] He there postulates a westerly dip of the chalk surface, which determined the flow of the streams in a westerly direction towards the long gap which was being formed in Miocene times, near the junction of the Mesozoic with the Palæozoic rocks. The still more important streams from the Welsh highlands had no doubt done much towards initiating that gap; and by the end of the Miocene period, if one may venture to assign a date, the valley of the Severn, which is one of the oldest in England, had already begun to take form, though many of the valleys of Wales are probably much older.

[1] Quart. Journ. Geol. Soc., vol. lii (1896), p. 68, and vol. liii (1897), p. 377.
[2] Proc. Geol. Assoc., vol. vi (1881), p. 375.
[3] Quart. Journ. Geol. Soc., vol. xxviii (1872), p. 148.

We may now be supposed to have arrived at a period when the physical features of this immediate district did not differ very materially from what they are at present. The great Ice Age was in full force throughout Northern Europe, and, according to views which meet with increasing favour, the German Ocean and the Irish Sea were filled with immense glaciers. What was taking place at that time in the estuary of the Severn?

This is a case which requires the exercise of the scientific imagination, of course under due control. There is probably nothing more extraordinary in the history of modern investigation than the extent to which geologists of an earlier date permitted themselves to be led away by the fascinating theories of Croll. The astronomical explanation of that 'will o' the wisp,' the cause of the great Ice Age, is at present greatly discredited, and we begin to estimate at their true value those elaborate calculations which were made to account for events which in all probability never occurred. Extravagance begets extravagance, and the unreasonable speculations of men like Belt and Croll have caused some of our more recent students to suffer from 'the nightmare.'

Nevertheless Croll, when he confined his views to the action of ice, showed himself a master of the subject, and his suggestions are often worthy of attention, even when we are not convinced. Writing in the GEOLOGICAL MAGAZINE in 1871, he points out that the ice always seeks the path of least resistance; and he refers to the probability that an outlet to the ice of the North Sea would be found along the natural hollow formed by the valleys of the Trent, the Warwickshire Avon, and the Severn. Ice moving in this direction, he says, would no doubt pass down into the Bristol Channel and thence into the Atlantic. Again,[1] referring to the great Scandinavian glacier, he says: "It is hardly possible to escape the conclusion that a portion of it at least passed across the south of England, entering the Atlantic in the direction of the Bristol Channel." These views were not based on any local knowledge, but merely on general considerations. The problem as to whether there are any traces of the passage of such a body of ice in the basin of the lower Severn must be worked out by local investigators. Irrespective, too, of the hypothetical passage of a lobe of the North Sea glacier, we are confronted by a much more genuine question, namely, what was the possible termination towards the south of the great body of ice with which our more advanced glacialists have filled the Cheshire plain.

A recent President of the Cotteswold Field Club, of whom unfortunately we must now speak as the late Mr. Lucy, took a lively interest in the Pleistocene geology of the district, and his papers in the Proceedings of the Cotteswold Field Club have always attracted attention. His map of the distribution of the gravels of the Severn, Avon, and Evenlode, and their extension over the Cotteswold Hills, prepared in conjunction with Mr. Etheridge, is a valuable contribution

[1] GEOL. MAG., Dec. II, Vol. I (1874), p. 257.

to the history of the subject.[1] Again, he wrote on the extension of the Northern Drift and Boulder-clay over the Cotteswold Range,[2] and on this occasion, described the interesting section in the drifts presented by the Mickleton Tunnel. In his previous paper Mr. Lucy had carried the drifts with northern erratics to a height of 750 feet, but he now claimed that "the *whole* Cotteswold Range had ceased to be dry land at the time the Clays and Northern Drifts passed over it." We perceive from this passage that Mr. Lucy was a 'submerger,' and in this respect differed from Croll, who most probably would have attributed the phenomena to the action of his great ice-lobe traversing the south of England.

The question which more immediately concerns us relates to the value of the evidence which would require either a glacier or a 'great submergence' to account for these things. The alleged phenomena are in many cases capable of other interpretations. We have the authority of Mr. Etheridge that little or no true Boulder-clay occurs in the Cotteswold area.[3] On the other hand, the distribution of much of the erratic gravel is probably due to agencies of earth-sculpture long anterior to the great Ice Age. There remains one special piece of evidence adduced by Mr. Lucy in favour of his contention, and this he considered of so much importance that it formed the principal part of the subject of his annual address to the Field Club on quitting the chair in 1893.[4]

He there referred more especially to the discovery *in* the Inferior Oolite, on Cleeve Cloud, of quartzose sand and of a boulder of a similar character to some described in his previous papers. The sand and the boulder, he says, belong to the period of the great submergence. Similar sand also appears in several places on the hillside. He had previously recorded boulders of Carboniferous Limestone, Millstone Grit, etc., in the northern Cotteswolds, but not at so great an elevation. He further proceeds to account for the absence of striæ, and of the fact that the Cotteswold rocks are not *moutonnée*, on the supposition that the soft oolites would not retain striation, but would be crushed by pressure. Consequently, he claims the top of Cleeve Cloud as a fine example of 'glacial denudation,' whatever that may mean. The boulder from Cleeve Cloud is now in the Gloucester Museum, and might well become a bone of contention between the submerger and the glacialist as to how it got into its elevated position of over 1,000 feet. Fortunately there is a third explanation, which, if it be correct, shows how dangerous it is to build theories, as well as houses, upon sand. Other distinguished members of the Cotteswold Club are of opinion that the whitish sands on Cleeve Common belong to the 'Harford Sands,' which constitute an integral part of the Inferior Oolite itself. There may be some difference of opinion as to the concretionary nature of the boulders,

[1] Proc. Cottes. Nat. Club, vol. v, pt. 2 (1869), p. 71.
[2] Op. cit., vol. vii, pt. 1 (1878), p. 50.
[3] Proc Cottes. Nat. Club, vol. xi (1893), p. 83.
[4] Vol. cit., p. 1.

though these may well be nothing more than the 'doggers,' or 'potlids,' so characteristic of calcareous sandstones. Mr. Winwood believes that "the so-called foreign boulder" in the Gloucester Museum evidently came from the 'Harford Sands.'

So far, therefore, the evidences of glacial action in the Cotteswolds do not rest on a very sure foundation. Yet the Severn Valley separates that range from an area on the west, where there are clear evidences of local glaciation, as described in the Annual Report of the Geological Survey for 1896. Portions of this material find their way into the river bed and elsewhere as Drift which has most probably been rearranged; hence the so-called Boulder-clay and Drift in the bed of the Severn. Once more, then, in the cycle of geological time we perceive that our district lies on the confines of two distinct sets of phenomena. West of the Severn and north of the Bristol Channel the evidences of considerable local glaciation are obvious, whilst this can hardly be said of the Cotteswolds, the Mendips, or the Quantocks.

To the more recent geological history of our district it will be sufficient to allude in the briefest terms, when I remind you of the paper by Mr. Strahan on the deposits at Barry Dock, and the still later one by Mr. Codrington on the submerged rock valleys in South Wales, Devon, and Cornwall. Here we have important testimony to certain moderate changes of level which have taken place, and a picture is presented to us of the Bristol Channel as a low-lying land-surface, with streams meandering through it. Thus a depression of something like 60 feet appears to be the most recent change which the geologist has to record in the estuary of the Severn.

REVIEWS.

I.—Contribution à l'Étude Micrographique des Terrains Sédimentaires. I. Étude de quelques dépôts siliceux secondaires et tertiaires du Bassin de Paris et de la Belgique. II. Craie du Bassin de Paris. Par Lucien Cayeux, D. ès Sc. 4to; pp. 589, pls. x, and 20 figures in the text. (Lille: Le Bigot Frères, 1897.)

IN this elaborate work Dr. Cayeux gives the results of an extended series of investigations into the minute structure of the sedimentary rocks mainly of the Paris Basin, but including as well some in the North of France and adjoining areas in Belgium. The age of the rocks treated of ranges from the Jurassic to the Eocene, but the greater number belong to the Cretaceous Series, from the Albian to the Senonian, or, in English terms, from the Gault to the Upper Chalk with *Belemnitella mucronata*. The author's aim has been, by a close study of the present characters of the deposits, to ascertain their natural history, and to trace the effects of the various mechanical, chemical, and physiological agencies to which they

have been subjected, and thus to gain an idea of their original structure and of the conditions under which they were formed. The work has been carried on by means of microscopic sections, chemical analyses, and more particularly by the study of the residues after treatment of the calcareous rocks with acid.

The first part of the volume contains a description of the siliceous deposits known in France and Belgium under the names of 'Gaize,' 'Meule,' 'Smectique,' 'Têtes de Chat,' 'Rabots,' and 'Tuffeau.' Other synonyms of the Gaize are 'Grès Vert,' 'Craie tufau,' 'Pierre morte,' and 'Pouzzolane.' Typical Gaize is a soft, porous, dirty gray or yellow siliceous rock of a sandy texture, with a varying amount of soluble silica in its composition. It frequently contains harder compact nodules, comparable in some respects to chalk flints, but unlike them in not being sharply delimitated from the softer matrix. It is as a rule rich in the débris of siliceous organisms, with variable amounts of quartz (sand-grains) and glauconite, also in some instances a small proportion of carbonate of lime. These constituents are usually cemented together by opalized or by chalcedonic silica. It may be said in passing that the 'Gaize' corresponds with those siliceous beds in the Lower and Upper Greensand of this country generally referred to as 'Chert,' 'Malm,' 'Sponge-rock,' etc.

Deposits of Gaize are prominently developed on three distinct horizons in France: (1) in the Oxfordian beds of the Middle Jurassic Series in the Ardennes; (2) in the Albian (= Lower Gault), also in the Ardennes; and (3) in the Cenomanian (= Upper Greensand) in Argonne and Pays de Bray.

The Jurassic Gaize, in the zone of *Amm.* (*Cardioceras*) *Lamberti* and *Amm. Mariæ*, is only known in the Ardennes, where it attains a thickness of about 50 metres. The soluble silica varies in different specimens from 9 to 56 per cent., and glauconite forms one-tenth of the rock. The organic constituents are principally minute rounded, oval or kidney-shaped, siliceous bodies, which are sufficiently numerous to constitute one-third to one-half of the rock, and with these are fractured siliceous sponge spicules. In some examples both the matrix and the rounded bodies are replaced by calcite. The author recognizes the similarity of these rounded and reniform bodies to those first described by Dr. Sorby from the corresponding horizon in the Calcareous Grit of Yorkshire, but he does not consider them to belong to *Geodia* sponges, owing to the absence of the corresponding skeletal spicules, and to the hollow condition in which many of these bodies now occur. It has, however, been shown that definite sponges occur in the Yorkshire beds apparently wholly made up of these peculiar rounded bodies (Quart. Journ. Geol. Soc., vol. xlvi, 1890, p. 54), a fact which Dr. Cayeux seems to have overlooked.

The Gaize of the Albian zones of *Amm. mammillaris* and *Amm. interruptus* is partly a soft porous rock, partly a coarse glauconitic grit; one sample yielded 28 per cent. of soluble silica. Spicules of

Monactinellid, Tetractinellid, and Lithistid sponges abound in the beds; they are now mainly of opal, but some are of chalcedonic silica. Not infrequently the spicules have been dissolved, and their empty casts remain in a cement or groundmass of amorphous silica.

The Gaize of Argonne in the Cenomanian zone of *Amm. inflatus* has a thickness of 80 to 105 metres. The amount of soluble silica ranges from 5 to 56 per cent. Sponge-remains in some beds constitute half the rock; they are of opal, chalcedony, pyrites, glauconite, or merely hollow casts. There are also a few Radiolaria, some doubtful diatoms, and, where lime is present, a few Foraminifera, belonging to *Textularia*, *Globigerina*, etc. The cement is mostly of colloid silica, frequently in the condition of minute globules, like those in the sponge-rock of the Upper Greensand of this country.

The Gaize of the zone of *Amm. Mantelli* in the Department of Cher, is very similar to that of Argonne. The soluble silica in it varies from 15 to 35 per cent.; the sponge-remains constitute from one-tenth to one-eighth of the rock, and there are likewise a few Radiolaria. The cement of this Gaize is also largely of globular colloid silica.

In the Gaizes above mentioned sponge spicules form the essential element. They vary considerably in numbers in different beds: in some they are estimated to form one-half, in others not more than one-tenth of the rock. Radiolaria and diatoms are present, but in very insignificant proportions, and occasionally a few Foraminifera. In the softer and friable kinds of Gaize the silica of the cement or groundmass is colloid in character, but in the harder kinds it is in the form of chalcedony. The author does not consider that the silica of the cement in the Gaize is entirely due to sponge remains, but that a certain proportion of it is derived from the decomposition of the argillaceous constituents of the rock; the evidence for this, however, is not by any means convincing.

The Meule de Bracquegnies, near Mons, belonging to the zone of *Amm. inflatus*, is practically of the same character as the Gaize of Argonne. The soluble silica ranges up to 25 per cent.; some beds are nearly wholly composed of sponge débris, in others this forms about one-half the rock.

In the vicinity of Liège and in the district of Herve (Belgium) the rock known as Smectique, belonging to the zone of *B. quadrata* (= Upper Chalk), consists of marls and glauconitic sands from 20 to 30 m. in thickness. It contains 15 per cent. of soluble silica. The rock is rich in sponge remains, now converted into chalcedony; it has also some well-preserved Radiolaria, a few diatoms, and a considerable number of Foraminifera. Unlike typical Gaize, the cement in this rock is mainly calcareous.

The deposits of 'Tuffeau' of Eocene age which occur in the North of France and in Belgium are very similar in character to the Gaize and Meule. They may be described as greenish or greyish glauconitic sands with argillaceous and calcareous materials, and a cement of soluble silica. Some beds are hard and tenacious, others

friable. Sponge spicules, and in some instances diatoms, appear to have furnished the soluble silica, which varies in amount from 11 to 27 per cent.

A chapter is devoted to the study of the glauconite so common in the Gaize and Tuffeau. The author brings forward evidence to show that a considerable proportion of this material has been formed long after the deposition of the beds in which it now occurs, and consequently that its origin is entirely independent of organic matter.

Chapter VI contains a description of the Radiolaria occurring in the Smectique de Herve. Though limited in numbers, there is a great variety of forms present, which are placed under twenty-seven genera. The predominant forms belong to the Discoidea, and mainly to the family Porodiscida; the Cyrtoidea are also well represented. Two or three new genera are proposed: one of these, *Monostylus*, appears to be a synonym of *Dorysphæra*, Hinde (Ann. and Mag. Nat. Hist., ser. VI, vol. vi, 1890, p. 52). The rock containing these Radiolaria is regarded as a terrigenous rather than a pelagic deposit, since sand grains are present in it; the organisms are, however, altogether too few to give the rock any pretension to be radiolarian in character.

The second part of the volume contains a detailed description of the composition of the Turonian and Senonian Chalk of the Paris Basin. The different areas treated of are: the North, Pays de Bray, Rouen and district, South-East, South-West, West, and North-West of the Basin. The Turonian Chalk is subdivided into the zones of *Actinocamax plenus*, *Inoceramus labiatus*, *Terebratulina gracilis*, and *Micraster breviporus*, and the Senonian into those of *Micraster cor-testudinarium*, *M. cor-anguinum*, and the Chalk with Belemnitellas. The composition of the Chalk of the respective zones in each area is given, showing the various kinds of organic remains, the nature of the minerals in the residues, whether formed in the rock or of clastic derivation, and also the nature of the cement.

Excepting in the Turonian beds of the Nord and Pays de Bray, the proportion of mineral residues in the Chalk of the Paris Basin—leaving the argillaceous material on one side—is less than 1 per cent. Quartz or sand grains are the most important constituents. The grains range on an average between 0·04 mm. and 0·12 mm. in diameter, but in all the deposits there are some reaching to 0·2–0·4 mm. They are mainly angular, with blunted edges; some are rounded, and a few crystals have been formed *in situ*. Many other kinds of mineral grains are associated with the quartz, such as zircon, tourmaline, rutile, magnetite, apatite, chlorite, etc.

Quartzite pebbles (galets) and fragments of schist occur not infrequently in the Senonian beds in the vicinity of Lille. Most of them are between 2 and 8 grams in weight; the largest noticed weighed 300 grams (= 10 oz. av.). They resemble some of the primary rocks of the Ardennes.

The principal secondary minerals formed in the Paris Chalk, in addition to flints, are glauconite, phosphate of lime, calcite, pyrite,

limonite, manganese, quartz, opal, etc. Glauconite occurs throughout, both as casts of organisms and as independent grains. The phosphate of lime is either amorphous or crystalline; some of the grains are free from all connection with organisms and formed in place. The nodules of this material have a strong preservative influence on the organisms, whether calcareous or siliceous, which they inclose. They are more numerous in beds which indicate some disturbance or interruption of the normal conditions of deposition.

The calcite in the Chalk occurs in isolated rhombohedric crystals, which are very generally distributed; these are oftentimes dissolved, leaving perfect geometrical cavities. This dissolution frequently takes place in an apparently capricious manner; certain bands of Chalk retaining the crystals, whilst in alternating bands they are completely removed. The rock with the hollow casts is usually soft and friable, that with the crystals hard and durable; and in beds where the calcite crystals have been partially dissolved, the portions intact appear as nodular masses inclosed in a soft matrix.

With respect to the flints, the author considers that they may have been formed at several periods in the history of the Chalk in which they now occur, and, further, that in the Paris Basin the amount of silica they represent bears a close relation to the number and volume of the sponge spicules in the same beds which have been replaced by calcite. The rarity or absence of flints in the Chalk cannot be taken as a reliable index of the part played by sponges in the particular beds, for the silica of the sponge remains may be dispersed through the Chalk in the form of minute colloidal globules, instead of being aggregated into flints, or it may have been carried by solution into lower beds.

Of the organic remains in the Paris Chalk, the débris of Molluscan and Brachiopod shells occurs throughout; more particularly is this the case with the detached prisms of the shells of *Inoceramus*, which in certain beds near Lille, at the top of the Turonian and at the base of the Senonian, are sufficiently numerous to form nine-tenths of the Chalk.

Polyzoa are very largely developed in some of the Turonian Chalks of the South-West of the Basin, where even the finer particles of the beds are mainly composed of their comminuted remains. Echinoderm fragments are present at all horizons, but they are less abundant in the Turonian than in the lower part of the Senonian. Corals play an uncertain part, possibly on account of their aragonitic character.

Though detached sponge spicules occur throughout the Chalk of the Paris Basin, it is necessary to dissolve a considerable amount of the Chalk to obtain them in the residues. Occasionally large numbers are present: for instance, in some beds at Meudon they are estimated to form one-fifth of the rock, and in the *M. cor-anguinum* zone at Maintenon, one-fourth. The most constant horizon for sponge-remains in the Paris Basin is at the summit of the Turonian. The *I. labiatus* and *T. gracilis* beds of the South-West and West of the Basin are distinguished by the abundance of Lithistid

spicules and the scarcity of Hexactinellid forms; whilst, on the other hand, the zone of *M. breviporus* is characterized by Monactinellid and Tetractinellid spicules. In the Senonian, Hexactinellid spicules appear in the residues. Detached spicules of Calcisponges are found in all the Chalk beds.

The remains of siliceous sponges are now only exceptionally preserved in colloid silica; most commonly they are replaced by calcite or by glauconite, and more rarely by pyrites, phosphate of lime, or by limonite. The author notes the rarity of empty casts of spicules in the Chalk as compared with those in the Gaize, but this may be less than appears, since the empty casts are very inconspicuous in the Chalk, and careful observation with a lens is needed to distinguish them.

The author also calls attention to the fact that Lithistid spicules are not replaced by glauconite the same as spicules of other groups of sponges in the Chalk. The explanation of this appears to be that the replacement of siliceous spicules by glauconite is effected by way of infilling of their axial canals; and as in the skeletal spicules of Lithistids the axial canals are, as a rule, very slightly, if at all, developed, replacement by glauconite does not occur. The spicules (so termed) in nearly all the groups from the Chalk figured by the author are, in fact, merely the solid infilling by glauconite of the enlarged axial canals of genuine spicules: this is shown by the even thickness and the truncation of the ends of the spicular rays. The contrast between these glauconitic replacements and actual spicules may be seen in the figures of a group of the latter (fig. 13, p. 290) from the upper zone of the Turonian Chalk of Rouen.

A few Radiolaria have been observed at different horizons in the Chalk; they are more numerous in the Senonian. In some instances they retain their siliceous structure; in others this has been replaced by calcite or phosphate of lime.

The proportion of Foraminifera in the Chalk examined varied from 5 to 80 per cent.; the maximum amount was found in the Turonian Chalk of the Rouen district. Forms of *Globigerina* are stated to play a subordinate *rôle* as compared with those of *Textularia* and *Rotalia*. The thickness of the foraminiferal tests varies considerably in different beds, and probably indicates variations of depth in the seas of the period.

Diatoms have been but rarely observed; on the other hand, Coccoliths and Rhabdoliths are present everywhere, the former by far the most numerous. The author regards them as pelagic Algæ.

The cement or matrix of the Paris Chalk is composed of fine particles derived from the breaking up of the various organisms, the microscopic Algæ, and crystals of calcite; it varies in amount from one-tenth to nine-tenths in different beds and localities. In every sample of chalk examined the organisms present show traces of dissolution, and there is no evidence of any direct chemical deposition of carbonate of lime from the sea-water.

The author unhesitatingly considers the typical Chalk of the Paris Basin, such as that of the Pays de Bray, the Rouen district, and the

East and South-East areas, as pelagic sediments. This typical Chalk consists of 90–98 per cent. of carbonate of lime; the proportion of silica is, in general, insignificant, save in the *I. labiatus* zone, which shows an analysis of 14 per cent.; the argillaceous materials do not, as a rule, exceed 1 per cent. The Senonian chalks, which are now poor in micro-organisms, were probably originally foraminiferal in character. The changes which have taken place in the original sediments tend to produce a crystalline calcite in which all traces of organization have disappeared.

In the two concluding chapters of the work a comparison of the Chalk with the recent *Globigerina* ooze is made, and the conditions of the Cretaceous sea considered. The author's opinion that the depth of this sea at the time of the greatest depression, when the *Belemnitella* chalk was forming, did not exceed 150 fathoms, certainly does not err on the side of excess.

The work is illustrated by some excellent phototypes of sections of different kinds of Gaize and beautifully executed lithographic plates of Radiolaria, enlarged sections of Chalk, glauconite, and other minerals. G. J. Hinde.

II.—The Geology of the Country around Bournemouth. By Clement Reid, F.L.S., F.G.S. Memoirs of the Geological Survey. 8vo; pp. iv, 12, with 14 illustrations. (London, 1898. Price 4*d.*)

In our July number we noticed the recently published Geology of Bognor issued by the Geological Survey; we have now to announce a companion memoir on Bournemouth, in explanation of the New Series Map Sheet 329. The Director-General, in his preface, briefly refers to previous geological works, while the author gives a concise account of the geological features. Reference is especially made to the labours of Mr. J. Starkie Gardner, who has done more than any other geologist to make known the life-history of the Eocene strata on the Hampshire coast. Figures are given of a number of the characteristic Barton fossils, and it is interesting to observe that most of the species were illustrated more than 130 years ago by Brander. The strata noted are the Upper Chalk, the entire Eocene series, the Headon Beds, and various Pleistocene and Recent deposits.

CORRESPONDENCE.

THE SUBMERGED PLATFORM OF WESTERN EUROPE.

Sir,—Mr. Jukes-Browne's letter in the September number of the Geological Magazine must not be left without some reply, notwithstanding that I have since dealt with its subject in some detail at the Bristol meeting of the British Association. The facts and

arguments I there brought forward may possibly modify his views on the question of the submerged physical features of the North Atlantic.

Mr. Jukes-Browne objects to the term 'escarpment' as applied to the great declivity along which the Anglo-Continental platform terminates, both on the ground of its great lateral extension and because of its elevation. These are only matters of degree. The question is really one of form, and to my mind on the ground of form the term is correct; the declivity has a terraced upper surface, has a descent, sometimes almost precipitous, and falls off in a slope, sometimes gentle, at its base into the abyssal plain. Putting geological structure aside, which in this case is inadmissible, this is the form of the escarpments of the Oolite, New Red Sandstone, Millstone Grit, and older rocks in this country and of parts of Europe. I do not know on what ground the writer objects to the range of the Nummulite Limestone along the south of the Nile Delta being called 'technically' an escarpment. Perhaps he has not himself seen its eastern extremity of Jebel Attaka, where it overlooks the Red Sea, and is one of the grandest escarpments I have ever seen as viewed from Suez.

The writer objects to the statement that I have expressed regarding these submerged physical features having been formed under terrestrial conditions; but he omits to mention the one crucial test of their terrestrial formation, namely, the river channels sometimes traceable up to or in proximity to the existing rivers draining the adjoining lands. He was probably not aware when he wrote his letter to what extent I have been able to determine these channels or cañons along the whole coastline from the English Channel to the Tagus. Such channels, with well-defined walls and ever deepening floors as we proceed outwards, cross the continental platform and the great escarpment opening out on the floor of the ocean at depths of 1,000 to 1,500 fathoms. One of these, commencing at the embouchure of the Adour, is so continuous and remarkable that Elisée Reclus, not recognizing its true nature, contents himself with exclaiming "What shall we say of that deep gulf?" etc., and leaves the question for answer to the future! I quite admit that in the absence of this succession of great channels, each one of which becomes accumulating evidence of its true nature, the question of the origin of the escarpment might have remained problematical, and it might have been supposed, for instance, that it represented the edge of a great depression of the ocean bed. But the river channels, which we cannot conceive could have been formed beneath the ocean itself, are, as it seems to me, the unquestionable proof of subaerial origin, both of themselves and of the physical features with which they are connected. Let Mr. Jukes-Browne procure the Admiralty Charts for himself and trace out the isobathic contours by means of the soundings, and then state his conclusions regarding the views which have been impressed on my own mind.

As regards the geological periods during which the features were elaborated, I cannot here discuss the question. I admit that I have